CCR Number: 0021	CRITICALITY: ROUTINE	DUE 11/23/98

DISTRIBUTION SHEET
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NEW MILLENNIUM PROJECT CONFIGURATION CHANGE REQUEST

PROGRAM EO-1	**TITLE** BASELINE EO-1 HYPERION INSTRUMENT ICD-065
CCR NO. 0021	**ORIGINATOR** K.BRENNEMAN/SWALES
DATE INITIATED 11/09/98	**ORIGINATOR'S CHG. NO.** TRW-IF1-0228
	SPONSOR/CODE P. Spidaliere **PHONE** x4797

EFFECTIVITY

ITEM: EO-1/HYPERION

S / N

ITEM:

S / N

ITEM:

S / N

CHANGE CLASS

	I	II
PRELIMINARY	☐	☐
FORMAL	☐	☐

TYPE OF CHANGE

MILESTONE	☐	INTERFACE	☒	SOFTWARE	☐
DOCUMENT	☒	POWER	☐	OTHER	☐
COST ______	☐	WEIGHT	☐	______	☐

DOCUMENTS OR SOFTWARE AFFECTED

EO-1 ICD-065

PROBLEM

The attached draft version of EO1-ICD-065, Earth Orbiter -1 (EO-1) Hyperion Instrument Interface Control Document (ICD) requires baselining. The Hyperion Mission is to provide Hyperspectral imaging data for improved earth surface characterization. The Hyperion instrument is a push broom scanner which provides hyperspectral images of the earth from a 705 km sun synchronous orbit with a 10:01 AM descending node. The attached draft ICD describes the mechanical, electrical and interface characteristics of the Hyperion instrument.

PROPOSED SOLUTION

Approve the attached draft version of EO-1 ICD-65, EO-1 Hyperion ICD, by the EO-1 Level II Configuration Control Board (CCB). This draft issue will be formally released after CCB approval. Future changes will be initiated by submittal of Configuration Change Requests (CCRs) and Preliminary Interface Revision Notices (PIRNs) for CCB approval. This document is maintained by the EO-1 Configuration Management Office (CMO).

BOARD ACTION

APPROVE	☐
APPROVE WITH CHANGE	☐
DISAPPROVE	☐
WITHDRAW	☒

APPROVAL LEVEL REQUIRED

LEVEL I HQS	☐
LEVEL II GSFC	☒
LEVEL III	☐

CRITICALITY LEVEL

EMERGENCY	☐
URGENT	☐
ROUTINE	☒

PROCUREMENT CHANGE ORDER CLASSIFICATION

ROUTINE		URGENT		EMERGENCY	☐
OPTION 1	☐	OPTION 1	☐		
OPTION 2	☐	OPTION 2	☐		

COMMENTS

Withdrawn due to Project Reqts change.

CHAIRPERSON ____________ DATE 22 Dec 98

3/28/96

EO-1 ICD-65
Draft Issue
November 3, 1998

EO-1
HYPERION
(ICD)

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

EO-1 Hyperion Instrument
Interface Control Document
(ICD)

TBD and TBR Status

Section	Description	Subsystem	Assignment
1.5.3	Hyperion Operators Manual #	Ops	Pearlman
	Hyperion Alignment Plan #	A&T	Iverson
3.2	HSA Purge Port Location	Mechanical	Rasmussen
3.3	HEA ICD Drawing	Electrical	Kien
4.10	Cover Inertia	Mechanical	Rassmusen
5.2	Cable Diagram Details	Electrical	Kien
5.7	Grounding Diagram	Electrical	Kien
9.3.1	HEA/CEA to S/C Heat Flow	Thermal	Rasmussen
12.3.1	Functional Test Procedure #	A&T	Iverson

Table of Contents

1. Introduction

This Interface Control Documentation (ICD) describes the characteristics of the Hyperion Instrument and defines the interface design requirements for placement of the Hyperion Instrument on the EO-1 spacecraft.

1.1 Scope

This ICD contains the specific interface requirements for the Hyperion Instrument, including those of the Hyperion sensor assembly (HSA), power and control electronics (HEA), and the cryo-cooler control electronics (CEA). The requirements defined include mechanical characteristics, structural design criteria, mass properties, electrical connections, thermal control, commanding, telemetry, and power.

1.2 Applicability

This ICD applies to the Hyperion Instrument that will be flown on the EO-1 spacecraft.

1.3 Approval

This ICD will be approved and signed by authorized representatives of TRW Hyperion Project Office, GSFC EO-1 Project Office, and Swales EO-1 Spacecraft Project Office. The approved document becomes effective immediately and is binding on the participating organizations until a revision is mutually agreed to and properly identified and documented.

1.4 Revisions

Request for revisions to this ICD will be transmitted in written form and shall include the following:

- Name of initiating engineer/manager and organization
- Description of change
- Date by which change is needed
- Justification for change
- Relationship to previously submitted changes, if any.

The TRW Hyperion Project Manager shall review and negotiate the requested changes. Changes shall be approved by authorized representatives of GSFC. Upon completion of the signature cycle, the changes shall become effective immediately. The Hyperion system engineer shall be responsible for updating the ICD to reflect revisions; he shall also maintain documentation of all requests for revisions, whether approved or not.

1.5 Applicable Documents

1.5.1 Drawings

868800-1	Hyperion Sensor Assembly, EO-1
868590	HEA Assembly Drawing
868652	Cryocooler Control Electronics - Model Hyperion, ICD
A0743	Hyperion Instrument/Satellite Layout, EO-1
A0765	EO-1 Spacecraft and Hyperion ICD Drawing

1.5.2 Specifications

GSFC-426-EO-001	Mission Assurance Requirements for the Earth Orbiter (EO_1) Program
SAI-SPEC-158	EO-1 Verification Plan and Environmental Specification

AM-149-0020(155)	System Level Electrical Requirements, EO-1
SAI-STD-056	EO-1 Spacecraft Subsystem Allocation and Description (for reference, only)
AM149-0050(155)	Data Systems 1773 Interface Control Document, Earth Orbiter-1
ALI-S1002	Internal Interface Control Document: Focal Plane Subsystem to Instrument
CCSDS 102.0-B-2	Consultative Committee for Space Data Systems (CCSDS) Recommendation for Packet Telemetry and Tele-commands
MIL-STD-1773A	Military Standard Aircraft Internal Time Division Command/Response Multiplex Data Bus
EQ7-0459	Hyperion Instrument Specification
EQ3-057	Equipment Specification for the HSI VNIR Focal Plan Array
EQ3-0926	Equipment Specification for the HSI SWIR Focal Plan Array
SAI-PLAN-130	EO-1 Integration and Test Plan, Rev C.

1.5.3 Documents

D22886	SSTI Safety Assessment Report
D22893	SSTI/HSI Contamination Plan
N/A	AIRS Cryocooler Safety Assessment Report
D27446	Hyperion I&T Plan
TBD#	Hyperion Operators Manual
TBD#	Hyperion Alignment Plan

2. Hyperion Instrument Overview
2.1 The Hyperion Mission

The Hyperion Mission is to provide Hyperspectral imaging data for improved Earth surface characterization.

2.2 The Hyperion Mission Objectives

The EO-1 Hyperion Project is to provide a science grade hyperspectral instrument based on existing design and hardware. The instrument will provide earth observation data with quality calibration for improved Earth surface characterization.

2.3 Instrument Description

The EO-1 Hyperion instrument is a push broom scanner which provides hyperspectral images of the earth from a 705 km sun synchronous orbit with a 10:01 AM descending node. The orbit inclination is 98.2 degree, the orbital period is 98.9 minutes, and the orbit is 1 minute behind Landsat 7 ETM+. The velocity of the nadir point is 6.74 km/sec. Figure 2.3-1 shows the EO-1 spacecraft in its deployed configuration.

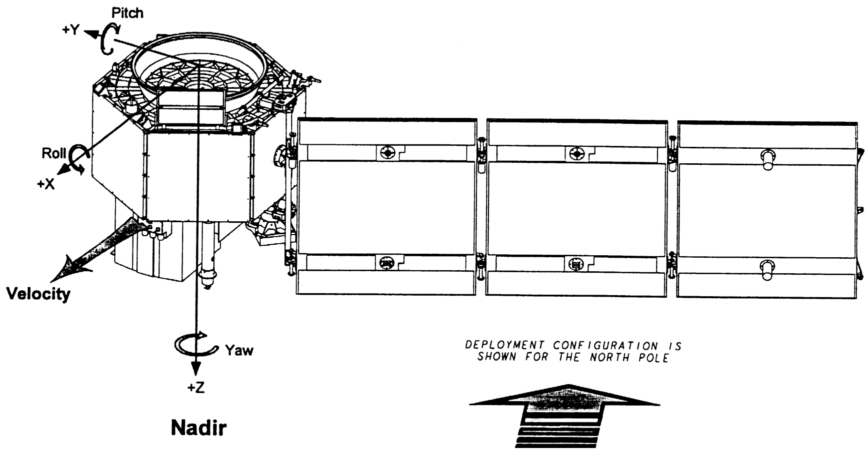


Figure 2.3-1 The EO-1 spacecraft in its deployed configuration

The Hyperion instrument has a VNIR and a SWIR focal plane with a common ground projection that is nominally perpendicular to the along-track direction. The instrument ground sample distance (GSD) is 30 meters. The Hyperion images are composed of 220 spectral bands covering the spectral range from 0.4 um to 2.5 um with the spectral resolution of 10 nm.

The Hyperion Instrument design utilizes a f/11 Three Mirrors Astigmat (TMA) reflective fore optic assembly with a 12.5 cm aperture. The Instrument has two (2) Grating Imaging Spectrometers (GIS) that share the same entrance slit located at the image plane of the fore optics. Each GIS contains a 2-D focal plane array (FPA) located at the image plane of the spectrometer entrance slit. One dimension of the focal plane array contains the cross track spatial data while the other dimension has the spectral data for each cross track spatial pixel.

The Hyperion Instrument provides simultaneous image data from 220 spectral bands over 256 cross-track spatial pixels. Normal sampling rate is 223.4 Hz. Data collection is limited by satellite power and data recording capacity.

The Hyperion Instrument is packaged into a Sensor Assembly (HSA) and two ancillary electrical boxes, the Hyperion Electronics Assembly (HEA) and the Cryocooler Electronics Assembly (CEA). All three Hyperion subassemblies are located on the nadir deck of the spacecraft, Figure 2.3-2. The HSA is thermally isolated from the nadir deck and contains the fore optics, the VNIR GIS, focal plane, focal plane and Analog Signal Processing electronics (VNIR ASP), and the SWIR GIS, focal plane, focal plane and Analog Signal Processing electronics (SWIR ASP). The HEA is the command, telemetry and image data interface between the Hyperion Instrument and the spacecraft. The HEA also converts the spacecraft bus voltages to the instrument voltage requirements and contains temperature control, calibration source drive, and aperture cover drive electronics. The drawing A0743, “Hyperion Instrument/Satellite Layout, EO-1” (Figure 2.3-2a,b) shows the locations of the HSA, HEA and the CEA on the EO-1 spacecraft. In order to align the Hyperion images with the EO-1 Advanced Land Imager (ALI) images, the Hyperion instrument boresight ($Z_{Hyperion}$-axis) shall be tilted with respect to the EO-1 satellite Z-axis in the -Y direction as defined in Section 4.5.

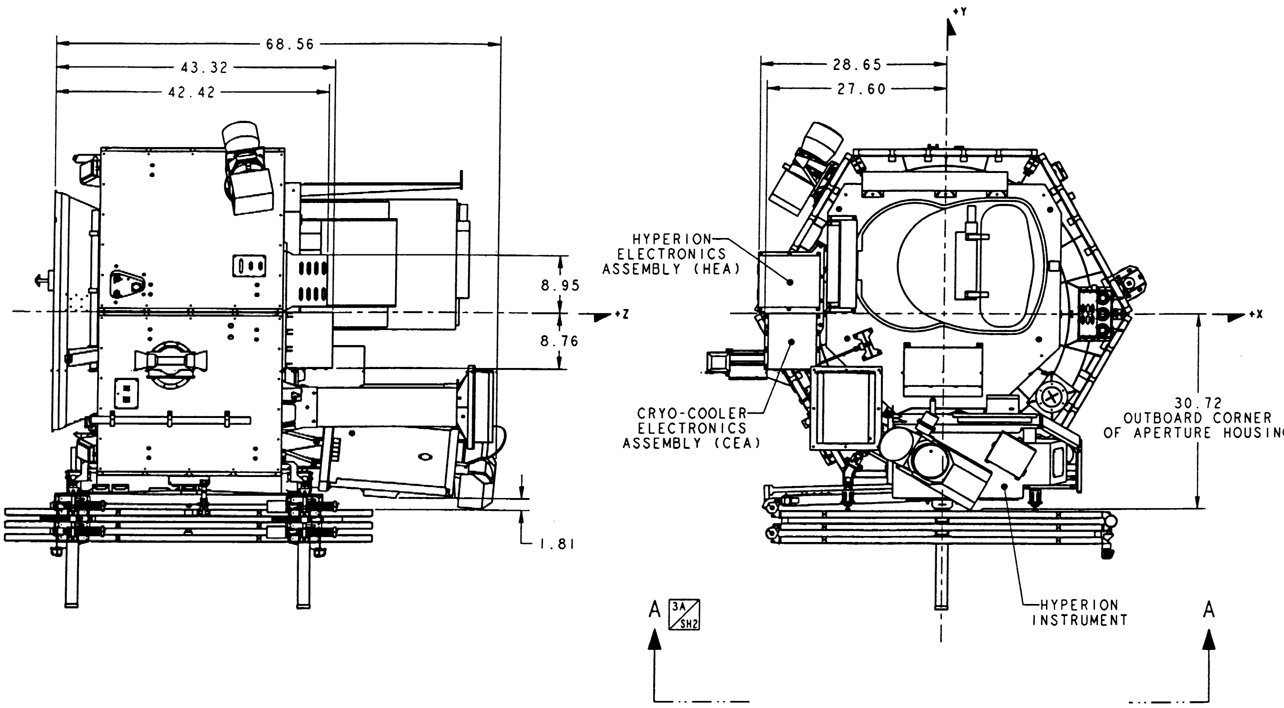


Figure 2.3-2a Location of the Hyperion HSA, HEA and CEA on the EO-1 spacecraft

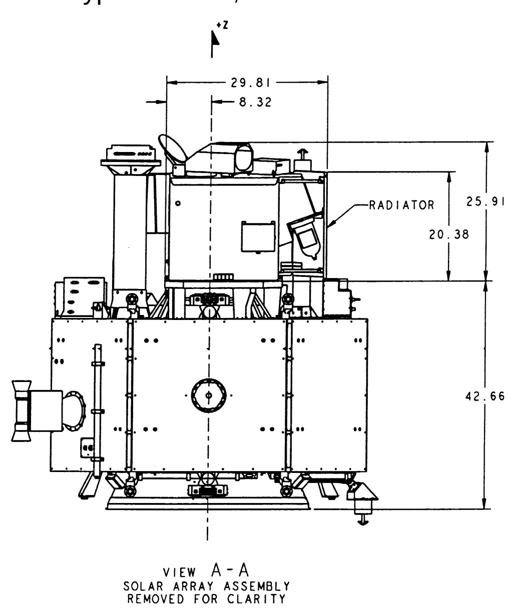


Figure 2.3-2b Location of the Hyperion HSA, HEA and CEA on the EO-1 spacecraft

3. Physical Description
3.1 Overview of Physical Configuration

The Hyperion Instrument consists of three assemblies on the EO-1 spacecraft: the HSA, the HEA, and CEA. A block diagram of the instrument is shown in Figure 3.1.1. The HSA is located on the spacecraft payload platform and is thermally isolated from the platform (see Figure 2.1.2). The HEA and the CEA are located on the spacecraft payload platform (see Figure 2.1.2) and are thermally connected to the spacecraft. The Hyperion instrument requires interconnected cable harness in addition to the harness between the spacecraft subsystems and the Hyperion. Both the interconnecting harness and the spacecraft to instrument harness are to be supplied by the instrument contractor and routed by the spacecraft subcontractor.

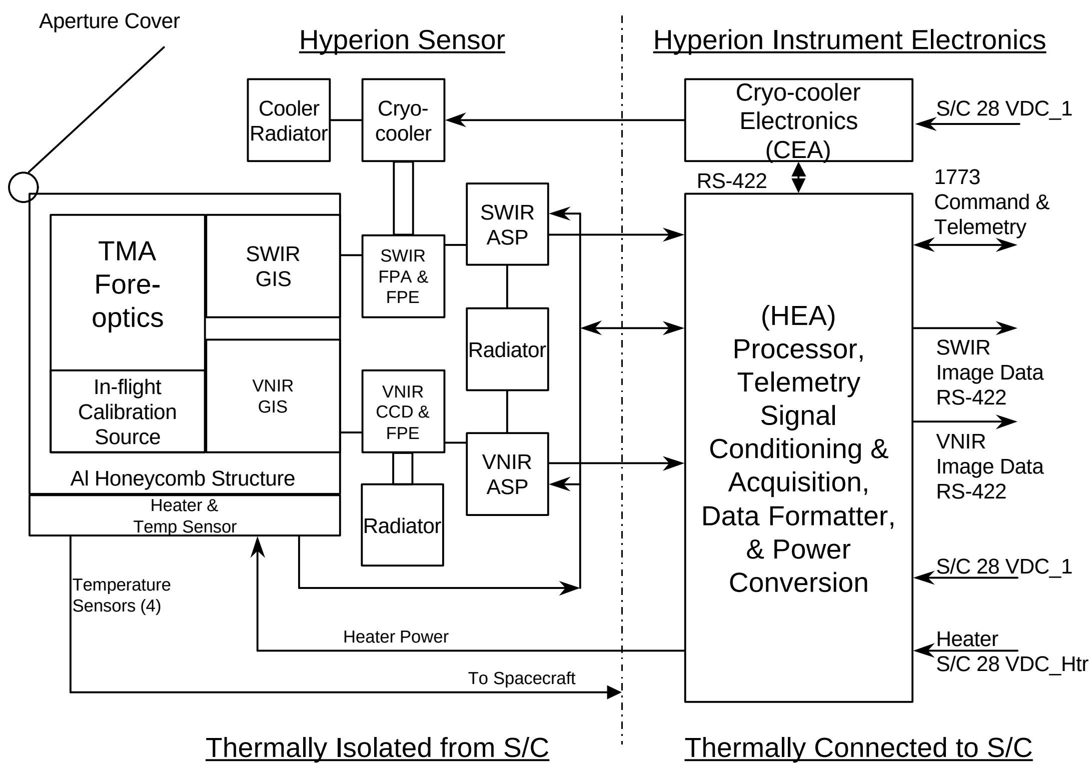


Figure 3.1-1 Hyperion Instrument Block Diagram

3.2 Hyperion Sensor Assembly (HSA) Description

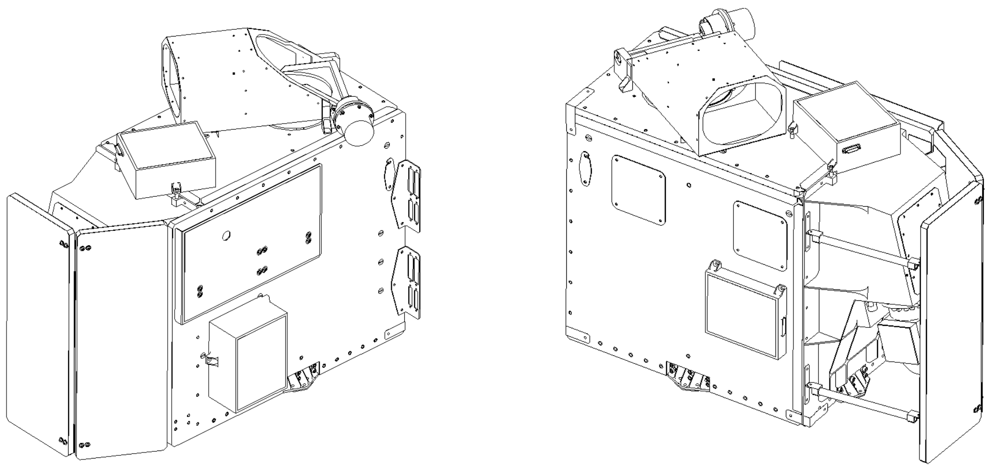
The HSA components are shown in Figure 3.1-1 and include the following:

- HSA Structural Assembly/Enclosure
- Aperture cover Assembly (includes Cover Motor)
- Opto-mechanical Subsystem (OMS) (includes in-flight calibration source)
- VNIR and SWIR Focal Planes and Focal Plane Electronics
- VNIR and SWIR Analog Signal Processors
- VNIR Radiator

- Cryocooler Mechanical Assembly and Radiator

The OMS is maintained at 20+/-2C by the HSA enclosure. The VNIR focal plane is operated at 273K (0C) and is thermally attached to the VNIR radiator. The SWIR FPA is operated at 115K (-158C) using cooling from the cryocooler.

The aperture cover protects the instrument optics from particulate and molecular contaminants as well as maintaining the OMS temperature environment. The cover is driven closed against a hard stop during the pre-flight ground operation, and only opens on orbit briefly for imaging/calibration events. The cover is driven by a stepper-motor and drive electronics. The aperture cover has three normal positions which are open, closed and solar calibration. The open position is used in taking imaging data. The closed position is used to reflect the internal calibration source into the fore optics for internal calibration of the focal planes. The solar calibration position is used to direct sunlight into the fore optics for the purpose of calibrating the instrument against the sun.



Where is the purge port?

Figure 3.2-1 Hyperion Sensor Assembly (HSA)

3.3 Hyperion Power and Control Electronics Assembly (HEA) Description

The Hyperion HEA houses the circuits needed for the following functions:

- condition spacecraft supplied power for distribution to the Focal Plane electronics Modules (FPM), the ASPs, the cover motor, heaters and the IFCS within the instrument;
- provide timing to clock and read the FPAs;
- control the ASP gains and offsets;
- control the in-flight calibration source;
- measure and maintain the HSA temperatures with controlled heaters;
- receive commands from the spacecraft; and
- digitize and distribute telemetry data over the 1773 bus.

The HEA is powered by 2 spacecraft 28+/-7 VDC services, and both power switching and over-current protection are controlled and provided by the spacecraft. One of the services powers the CEA along with the HEA, and the other service supplies heater power during both normal operations and during survival. The HEA measures and controls the HSA temperature with heater control, and as a result, shall be powered and functional to maintain temperature stability of the HSA.
Show more detail: e.g., connector locations

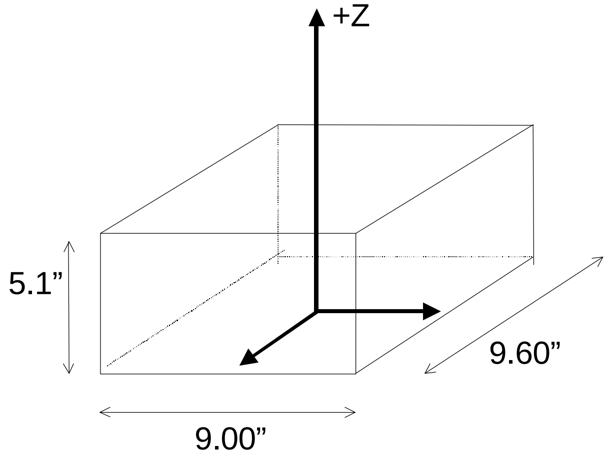
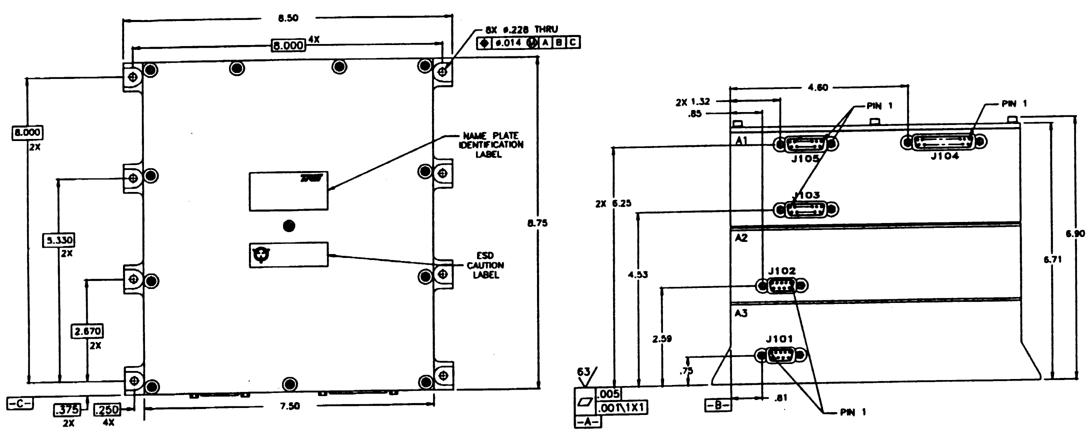


Figure 3.3-1 Hyperion Power and Control Electronics Assembly (HEA)

3.4 Hyperion Cryo-cooler Control Electronics Assembly (CEA) Description

The Hyperion Cryo-cooler control Electronics Assembly (CEA), Figure 3.4-1, powers and controls the cryo-cooler compressor assembly which supplies cooling to the Hyperion SWIR FPA. CEA power is on the same service as the main HEA power and the two assemblies are switched on and off together. Optimally, after the SWIR FPA is cooled down on-orbit, the FPA is to be maintained at the operating temperature because of the long thermal time constant of the FPA assembly and the FPA sensitivity to thermal cycling. The thermal cycling of the SWIR FPA is to be minimized and shall not exceed 100 thermal cycles. The SWIR FPA shall be limited to less than 15 thermal cycles during satellite I&T.



CONNECTOR IDENTIFICATION 2.		
REF	NAME	CONNECTOR TYPE
J105	COLD HEAD I/F	M24308/2-2(15S)
J104	ACCEL / CAP SENS I/F	M24308/2-3(25S)
J103	S/C I/F	M24308/4-2(15P)
J102	MOTORS	M24308/2-1(9S)
J101	S/C POWER	M24308/4-1(9P)

Figure 3.4-1 Hyperion Cryocooler Control Electronics Assembly (CEA) Interface
(Drawing #868652, Cryocooler Control Electronics - Model Hyperion, ICD)

4. Mechanical Interface
4.1 Overview of the Mechanical Interface

The Hyperion HSA, HEA and CEA units are mounted on the nadir deck of the spacecraft. The HSA is thermally isolated from the spacecraft but rigidly mounted to an instrument shelf on the nadir deck at four points using 12 10-32 fasteners. The HEA and the CEA are thermally connected to the spacecraft through the mounting surfaces of an instrument shelf and have thermal radiators to limit heat conducted into the nadir deck. The HEA is secured to the instrument shelf with #8 bolts and the CEA uses #10 bolts. All of the mounting hardware for the HSA, the HEA and the CEA are to be supplied by the spacecraft contractor.

4.2 Mechanical Interface Reference

The Hyperion EO-1 interface drawing is the controlling reference which specifies the Hyperion to EO-1 mechanical spacecraft interfaces. Other references are listed below,

A0765	Hyperion Instrument/Satellite Interface Control Drawing, EO-1
868800-1	Hyperion Sensor Assembly, EO-1
868590	Hyperion Electronics Assembly (HEA)
868652	Interface Control Drawing, Cryocooler Control Electronics - Model Hyperion

4.3 Instrument Reference Coordinate Systems

The location and orientation of the Hyperion instrument assembly's coordinate system relative to the EO-1 spacecraft reference coordinate system is contained in drawing A0765. The location of the HSA coordinate system is shown contained in drawing 868800-1, Hyperion Sensor Assembly, EO-1. The HSA optical alignment relative to the HSA reference coordinate system shall be specified relative to the optical alignment cube shown in drawing #868800-1.

4.4 Instrument Sizes

The detailed dimensions of the Hyperion Instrument assemblies are specified in drawing #868800-1, EO-1; #868590, and #868652. The maximum dimensions of the assemblies are as follows:

	Height (inch)	Base (inch)
HSA	25.5	15.2 x 29.5
HEA	5.1	9.0 x 9.6
CEA	6.9	8.50 x 8.75

4.5 Instrument Field of View

The fields of views (FOV) required by the Hyperion Instrument for earth viewing (imaging) and solar calibration are shown in drawing #868800-1. The Hyperion earth viewing FOV shall be offset 4.84+/-0.05 degrees from the spacecraft +Z axis towards the -Y axis. The FOV shall be less than 1.0 degree (full field) in the cross-track direction (+Y/-Y) and 0.5 degree (full field) in the along track (+X) direction. A keep out zone with an additional 15 degrees (full field) defined about the center of the imaging and solar calibration FOVs shall be provided by the spacecraft.

The solar calibration FOV shall be along the line in the spacecraft reference X-Y plane which is located at 23.15 in. along the Z-axis. The FOV will be 1.0 degree in the X/Y plane by 0.5 degree relative to the +Z/-Z axes. A circular keep out zone with an additional 30 degrees half angle shall be provided by the spacecraft.

The HSA, including the ASPs, is thermally isolated from the spacecraft and thermal control is accomplished using radiators which view deep space. The clearances necessary for the radiators FOVs are detailed in the Drawing A0765, Hyperion Instrument/Satellite Interface Control Drawing, EO-1.

4.6 Mass Properties

The maximum masses of the Hyperion Instrument assemblies are as follows:

	Mass (kg)
HSA	35.0
HEA	7.0
CEA	7.0

4.7 Center of Mass

The center of mass locations for the Hyperion Instrument assemblies in the assembly references are as follows:

	Assembly References (in +/- 0.10 in)
HSA	X=3.0, Y=0.0, Z=8.0 (Note 1)
HEA	X=0.0, Y=0.0, Z=2.5
CEA	X=0.0, Y=0.0, Z=3.5

Note 1. X, Y, Z=0 at where bore-sight intersects base of HSA

4.8 Mounting, Drill Template, Alignment, and Access
4.8.1 Mounting

The HSA shall be mounted using four flexure mounts (see drawing 868800-1) to the instrument shelf on the nadir deck.

4.8.2 Drill Template

The HSA mounting holes shall be transferred from the drill template provided by TRW. The drill template shall contain an alignment cube.

The HEA and CEA mounting holes shall be transferred from tooling holes for alignment. No drill templates are needed.

4.8.3 Alignment

The HEA and the CEA alignments are not critical and shall be according to the drawing A0765.

The HSA alignment requirements are specified in the drawings A0765 and 868800 and are discussed below. All alignment is with respect to the ALI boresight.

4.8.3.1 X-axis Alignment

The Hyperion boresight rotation about the X axis is the most critical and shall be controlled to 0.05 degrees. 0.05 degree converts to 180 arc-sec or 872.7 urad, and is (705 km x 872.7 urad) 615 m in the across-track swath location.

The HSA will be shimmed to within the correct tolerance, and in order to limit the amount of shimming to less than 0.61 degree, the following alignments are necessary.

(1) The HSA optical cube shall be mapped (measured) to the Hyperion boresight to within 0.01 degrees. 0.01 degree converts to 36 arc-sec or 174.5 urad, and is (705 km x 174.5 urad) 123.0 m in the along- and across-track dimension.
(2) The HSA mounting surface shall be perpendicular to the HSA boresight to within 0.1 degrees. (0.1 degree converts to 360 arc-sec or 1745.3 urad, and is (705 km x 1745.3 urad) 1230.4 m in the along- and across-track dimension.)
(3) The spacecraft mounting plate will be mounted to within 0.5 degrees of the correct angle.

4.8.3.2 Y-axis Alignment

The HSA shall be aligned to with 0.5 degree in rotation about the Y axis. This is within the manufacturing tolerances of the spacecraft mounting plate. (0.5 degree converts to 1800 arc-sec or 8276.5 urad, and is (705 km x 8276.5 urad) 6152 m in the along-track position.)

4.8.3.3 Z-axis Alignment

The HSA drill template shall be aligned to within 0.5 degrees in rotation about the Z axis using the optical cube on the drill template. (0.5 degree converts to 1800 arc-sec or 8276.5 urad, and is (0.5x7680m x 8276.5 urad) 31.8 m, or about 1 pixel, in the along-track position.)

4.8.3.4 Alignment Procedure

During the Hyperion/Spacecraft integration, the Hyperion shall be shimmed to within the correct tolerances per the Hyperion Alignment Procedure, #TBD.

4.8.4 Access

The Hyperion Instrument does not require external access to test points. Component and connector clearance requirements are detailed on the drawing 868800-1.

4.9 Base-plate Flatness

The mounting surfaces of the HSA, HEA and the CEA shall be fabricated to a flatness tolerance of +/- 0.005 inches or less to ensure the required electrical and thermal contacts as well as the required alignment accuracy of Hyperion line of sight with respect to the spacecraft coordinates. The spacecraft mounting plate shall be flat to the tolerance of +/- 0.010 inch. The HSA mounting surface characteristics are specified in drawing 868800-1. The HEA mounting surface characteristics are specified in drawing #868590. The CEA mounting surface characteristics are specified in drawing #868652.

4.10 Aperture Cover Operation and Uncompensated Angular Momentum

HSA aperture cover operation timing is summarized in Table 4.10.

Table 4.10 Hyperion Aperture Cover Operation Timing

Operation	Estimated Duration
Cover Open (Imaging)	15 seconds
Cover Close (Imaging)	15 seconds
Cover Open (Solar Calibration)	5 seconds
Cover Close (Solar Calibration)	5 seconds

The rotational inertia and maximum velocity of the aperture cover are TBD kg-cm2 and 0.16 radian/sec. The cryo-cooler compressor self induced vibration is <0.2 N on axis (0 to 1 kHz) and is <0.1 N off axis (0 to 1 kHz).

5. **Electrical Interface**

5.1 Overview of the Electrical Interface

The Hyperion electrical interface block diagram is shown in Figure 5.1-1. The Hyperion external electrical interface consists of 2 switched power services, a 1773 command and telemetry interface, and two (2) 32-cable (twisted pair) RS-422 image data interface. The Hyperion instrument does not employ any bi-level command line nor any pulsed command line. The command and telemetry interface and the science data interface are discussed in Sections 6 and 7 respectively.

The Hyperion instrument shall meet all the electrical interface requirements in the systems level Electrical Requirements, EO-1, AM-144-0020(155).

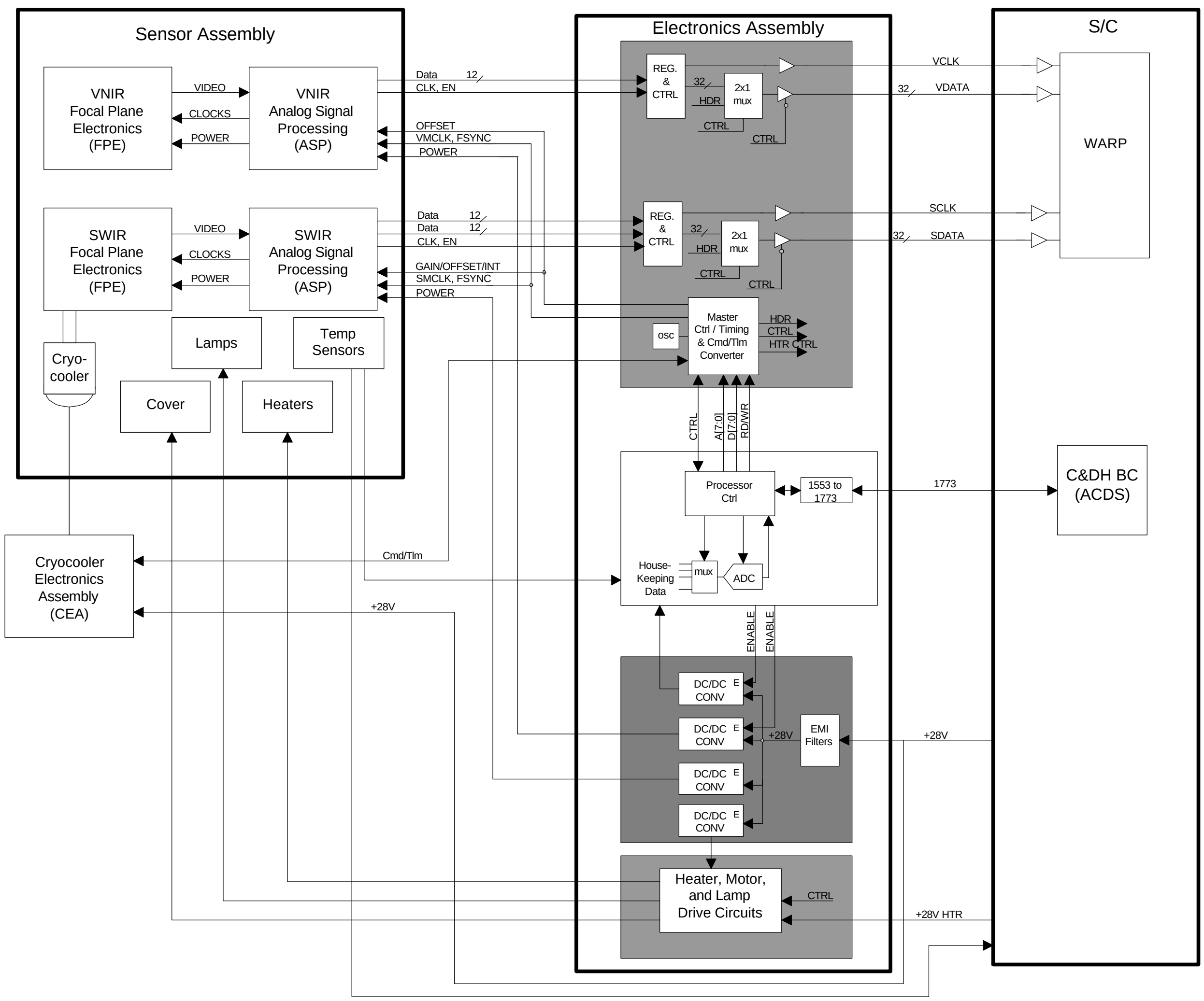


Figure 5.1-1 Hyperion Spacecraft Electrical and Data Interface Diagram

5.2 Electrical Interface Harness

The external harness assembly between the spacecraft and the Hyperion instrument consists of (1) the 1773 harness; (2) the image data RS-422 harness; and (3) the power supply harness. The Hyperion instrument contractor shall supply the harnesses and the harnesses shall be routed by the spacecraft contractor.

The Hyperion instrument shall provide, to the spacecraft, temperature monitoring at 4 critical points on the HSA. The temperature sensor (SP44905 YSI thermistors, GSFC S311P18-05A76R, 5K Ohms at 25C) wires shall be routed to a 9-pin D-connector for mating to the spacecraft. Detailed pin assignments of the connector is included in Appendix A. The spacecraft shall provide measurement and telemetry of these 4 temperature sensors.

There are three (3) internal harnesses between the Hyperion subsystems and they are (1) the HEA/HSA harness assembly; (2) the CEA/HSA Harness assembly; and (3) the HEA to CEA harness assembly. These 3 harness assemblies shall be supplied by the Hyperion instrument builder and the harnesses shall be routed by the spacecraft contractor.

The external harness connector specifications, wire specifications, and pin assignments are given in Appendix 1.

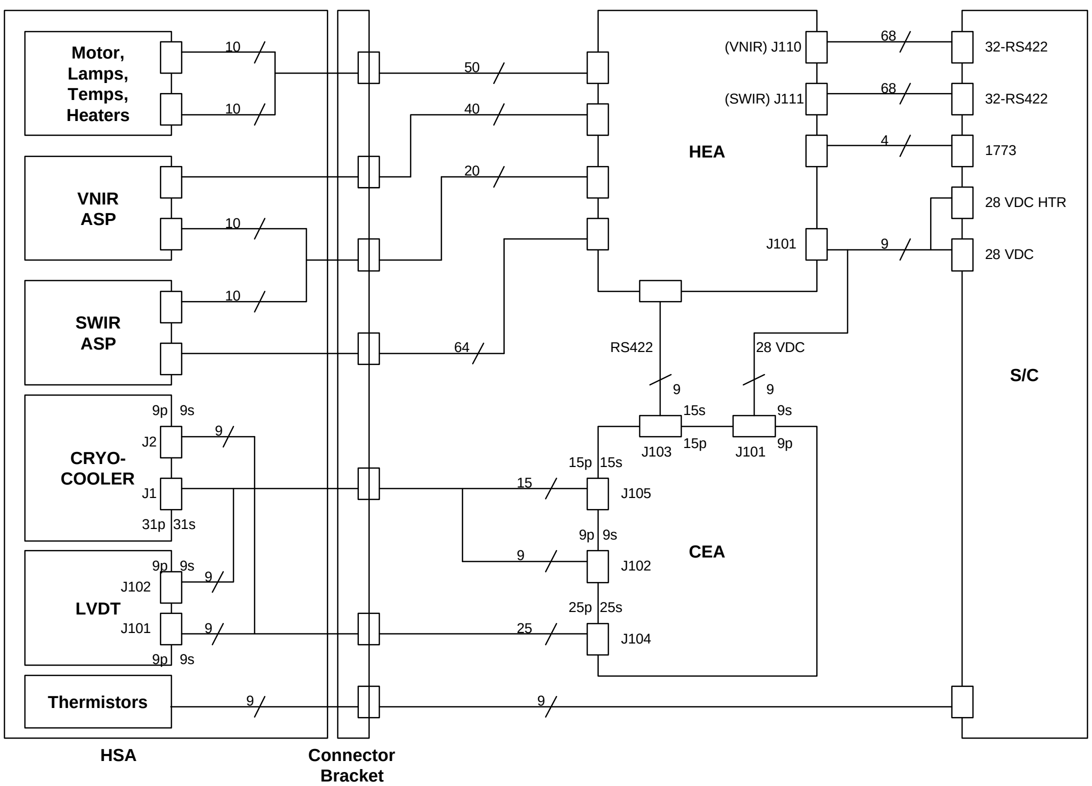


Figure 5.2-1 Hyperion Cable Diagram.

5.3 Power Control

The spacecraft shall provide Hyperion power line over-current protection and shall control switching of the power lines.

5.3.1 Over-current Protection

5.3.1.1 Over-current Protection Requirements

The over-current protection requirements for the 2 Hyperion switched power lines are listed in Table 5.2.1-1

Table 5.3.1.1-1 Hyperion Over-current Protection Requirements

	Over-current Protection Requirement (A.)
HEA_28V_1	15
HEA_28V_HTR	15

5.3.1.2 In-rush Current

The Hyperion instrument shall control the HEA_28V_1 and the HEA_28V_HTR power line in-rush current to meet the EO-1, AM-144-0020(155) requirements.

5.4 Spacecraft Bus Voltages

The Hyperion instrument electronics shall condition, convert and operates at the spacecraft bus voltage of 28 +/- 7 VDC.

The spacecraft bus voltage variations of +/-7 VDC shall include the +/- 1.5 V voltage ripple.

The Hyperion electronics shall survive without damage bus voltages of 0 volts to +40 VDC.

5.6 Hyperion Power Consumption

The Hyperion power consumption shall not exceed the values shown in Table 5.6-1.

Table 5.6-1 Hyperion Instrument Power Consumption

Operation Mode	Power (Watts)	Margin (5%)	HEA/CEA_28V	HTR_28V
Idle	59.4	2.8	52.8	3.8
Standby	96.9	4.6	88.5	3.8
Imaging	103.5	4.9	94.7	3.8
Lamp Calibration	141.0	6.7	130.5	3.8
Cover Operation	123.2	5.9	113.5	3.8
Survival	25.1	1.2	0.0	23.9

5.7 Grounding and Shielding

The HSA is isolated from the spacecraft platform and shall have a single point grounding strap connection to the nadir deck. The ground strap shall meet the requirements of EO-1, AM-144-0020(155).

The pickup point for the grounding strap shall be one of the HSA side-panel fasteners located on the –X side of the HSA module. Swales Aerospace shall supply the ground strap and the grounding lug on the spacecraft.

NEED AN INSTRUMENT GROUNDING DIAGRAM.

The Hyperion primary power return impedance shall meet the requirements of EO-1, AM-144-0020(155).

The Hyperion signal return shall be connected to the chassis according to the requirements of EO-1, AM-144-0020(155).

5.8 Electrical Isolation

At the interface, between power and signal lines, the Hyperion shall provide a DC and AC isolation that meet the requirements of EO-1, AM-144-0020(155).

6. Command and Telemetry
6.1 Command and Telemetry Overview

The Hyperion instrument requires up-link capabilities from the spacecraft operation control center through the spacecraft computer. The Hyperion uses two up-link modes: real-time command up-link and time-tagged command up-link for flight operations. The nominal operation mode of Hyperion will use time-tagged command up-link.

Commands up-linked are sent to the spacecraft which reformats the commands and distributes them to Hyperion as appropriate. The Hyperion uses a 1773 bus for command and telemetry interface and the protocol conforms to AM149-0050(155) "Data Systems 1773 Interface Control Command, Earth Orbiter-1" specifications. The 1773 harness shall be supplied by the spacecraft contractor.

When the spacecraft applies power to the power interface of the Hyperion HEA, the instrument transitions from the un-powered condition to the Idle Mode. Initial power up also enables the instrument processor, loads the instrument flight software, collects state of health data, starts the temperature and heater control, and enables the 1773 command and telemetry interface. After the initial power up, the 1773 bus is used to provide instrument command and telemetry support.

When the spacecraft applies power to the CEA interface, the CEA shall boot up from ROM software and shall be ready to establish RS-422 communication with the Hyperion HEA unit. The Hyperion CEA command and telemetry functions are supported and re-routed to the spacecraft by the HEA via the 1773 interface.

6.2 Discrete Command and Telemetry Interfaces

Discrete interfaces are bi-level command lines and pulse command lines. The Hyperion instrument has no bi-level and pulse command interface.

6.3 Power-off Command Sequence Restriction
6.3.1 Power-off Command Sequence

Before the ACDS main processor remove power from Hyperion, the spacecraft shall provide a close cover command to the Hyperion at least 30 seconds prior to a power off sequence. This is to prevent the Hyperion from direct viewing of the sun through the instrument aperture during anomalous spacecraft conditions.

Abrupt termination of Hyperion power can occur if a spacecraft low-power condition follows a loss of 1773 communications. Abrupt termination of bus power supply to the Hyperion without closing the aperture cover may result in damage to the Hyperion instrument.

6.3.2 Loss of 1773 Time Code "Tone Message"

The Hyperion shall monitor 1773 Time Code "Tone Message" broadcast each second at the schedule time of 0.000. In the event no "Tone Message" is detected for 10 seconds, the Hyperion shall initiate the internal command sequence to close the instrument cover and put the Hyperion in the Idle Mode.

6.3.3 Safehold Command

The spacecraft shall provide a Safehold command to the Hyperion in advance of the instrument emergency shut down procedure. After receiving a Safehold command, the Hyperion shall close the aperture cover and transit into the Idle Mode with the ASPs power off within 30 seconds.

6.4 1773 Command and Telemetry Data Bus

The Hyperion instrument shall use a MIL-STD-1773 fiber optics serial bus1773 to conduct command and telemetry functions. The Hyperion (RT) 1773 controller shall be a Litton 1300 nm, 900-60095-12 transceiver. The 900-60095-12 transceiver shall be supplied by GSFC. The 1773 bus shall meet the specifications in AM149-0050(155) "Data Systems 1773 Interface Control Command, Earth Orbiter-1". Measured parameters delivered with Hyperion shall include power output receiver sensitivity and receiver saturation values for both the A and B bus transceivers. The spacecraft subcontractor shall supply and route the 1773 interconnecting harness to the Hyperion.

The spacecraft Flight Data System (FDS) software residing on the ACDS main processor (Mongoose V) shall operate as the Bus Controller (BC) and the Hyperion instrument shall operate as a Remote Terminal (RT). The remote terminal address ID for the Hyperion shall be 12 (01100). The FDS BC software implements a time division multiplexed bus schedule for communication with the various subsystems on the spacecraft. The details of the Command and Telemetry Packet sizes, CCSDS application identification numbers (apid), Channels and packet transfer data rates are detailed in AM149-0050(155) "Data Systems 1773 Interface Control Command, Earth Orbiter-1".

6.5 Command and Telemetry Packet Protocol

The primary data transfers in the spacecraft are in the form of CCSDS packets. The Hyperion instrument shall format the telemetry data to comply with, and shall be capable of processing received data that was formatted according to, the CCSDS recommendations for packet telemetry. The spacecraft bus schedule for Hyperion is shown in Figure 6.5-1. The Hyperion shall use the BOX_CMD and the HYP_COOL_CMD schedules to receive command and instrument parameters from the spacecraft, and shall use the HYP_SOH_TLM and the HYP_SUBCOM schedules to send data to the spacecraft.

Time	Packet		Time	Packet
.048	BOX_CMD		.528	BOX_CMD
.128	BOX_CMD		.592	BOX_CMD
.208	BOX_CMD		.680	BOX_CMD
.248	BOX_CMD		.720	BOX_CMD
.280	HYP_CMD_SUBCOM		.784	BOX_CMD
.288	BOX_CMD		.856	BOX_CMD
.344	BOX_CMD		.904	HYP_TLM_SUBCOM
.424	BOX_CMD		.928	BOX_CMD
.464	BOX_CMD		.984	BOX_CMD
.520	HYP_SOH_TLM			

Figure 6.5-1 Hyperion Spacecraft Bus Schedule

The CCSDS packets shall be transferred over a channel (a set of sequential 1773 sub-addresses). Channels shall be multiples of 32 16-bit words (one complete sub-address). The most significant bytes of a packet (the packet header) shall be transferred in the lowest sub-address. The Hyperion channels are defined in Figure 6.5-2.

Figure 6.5-2 Hyperion Instrument Command and Telemetry Channel Definitions.

BC to RT Command Channels					
Channel Definition	Start Sub-address	End Sub-address	Completion Sub-address	Bus Schedule	RSN Queues
RCH1	1	1	2	Box Commands	Instrument commands
RCH2	3	20	21	0.280	Cryo-cooler commands

RT to BC Telemetry Channels					
Channel Definition	Start Sub-address	End Sub-address	Completion Sub-address	Bus Schedule	Typical Use
XCH2	3	18	19	0.904	Cryo-cooler telemetry
XCH3	20	23	24	0.520	Instrument telemetry

6.6 Telemetry Packet Format and Acquisition

The transfer of packets is governed by 2 protocols, a BC to RT packet transfer and a RT to BC packet transfer.

6.6.1 Telemetry Packet Format

The Hyperion telemetry packet shall conform to CCSDS packet telemetry recommendations. A primary header shall be attached to the telemetry data. In addition, the time code shall be included in the secondary header. The telemetry data packet header, data format and telemetry list is detailed in Appendix 2.

6.6.2 Telemetry Packet Acquisition

The channel sub-addresses shall be read consecutively. Only "new data" is recorded or transmitted. The first 16-bit word in the first sub-address shall be used as a semaphore. If the semaphore value is zero or the same as the previous read the channel does not contain "new data". The BC shall read from the completion sub-address to signal to the RT that the channel read is completed.

6.7 Command Packet Format and Distribution

6.7.1 Command Packet Format

The spacecraft distributes commands in CCSDS packets. The application ID and functional code of the command packet are used to identify the RT and channels. The command packet header, data format and command list is detailed in Appendix 2.

6.7.2 Command Packet Distribution

The BC shall write consecutively to the sub-addresses in a channel and the BC shall write to the completion sub-address to signal to Hyperion that the write transfer is complete.

6.8 Time Code Distribution

The FDS shall deliver a time code update to the Hyperion instrument once per second. The time code update shall be delivered in two command packets, a "tone message" and a "at the tone the time was" packet. The time code data shall correspond to the first bit of the "tone message" command packet. The channel definition and the application id for time distribution is shown in Figure 6.4-5.

Table 6.8-1 Time Code Distribution Channel Definition

Time Synchronization Command Remote Terminal 31 (Broadcast)					
Channel Definition	Start Sub-address	End Sub-address	Completion Sub-address	Max Packet Size (16-bit words)	Typical Use
Tone	29	---	---	32	Once per second

					Schedule 0.000
Time	28	---	---	32	Once per second Schedule 0.088

The 'tone message" packet is a command packet with a 6-byte primary and a 2-byte secondary header. The 'tone packet" contains no command data. The "at the tune the time was" packet has a 6-byte primary and a 2-byte secondary header plus a 16-bit sequence counter and a 64-bit time code.

6.9 Reset Command Packet

In addition to power up processor re-boot, the Hyperion shall respond to a Reset Command from the spacecraft. The channel definition and the application id for time distribution is shown in Figure 6.9-1.

Table 6.9-1 1773 Reset Command Channel Definition

Reset Remote Terminal Remote Terminal 31 (Broadcast)					
Channel Definition	Start Sub-address	End Sub-address	Completion Sub-address	Max Packet Size (16-bit words)	Typical Use
Reset	0	---	---	0	Schedule 0.480

6.10 Wrap Around Data

The wrap around data provision is to verify the proper operation of the 1773 bus. The Hyperion instrument shall use the receive sub-address #30 to receive BC data up to 32 16-bit words and make the same data available for read out by the BC at transmit sub-address #30.

7. Image Data Interface

The Hyperion shall provide image data collection capability in support of the Mission Objective. The image data shall be formatted and transmitted to the WARP for storage using two 32-cable RS-422 data bus, one for the VNIR data and one for the SWIR data. The total data volume for each image data collection shall be less than the Wideband Advanced Recorder/Processor (WARP) data storage capacity of 40 Gb.

7.1 32-Cable RS-422 Image Data Interface
7.1.1 Image Data Ports

The two 32-cable RS-422 image data buses shall be connected to the WARP interface port J4 and J5. Port J4 shall be the Hyperion VNIR data port and port J5 shall be the Hyperion SWIR data port.

7.1.2 Image Data Interface Circuit, Connector and Pin Assignments

The Hyperion 32-cable science data connector shall be a 78-pin socket type D-connector, and the connector pin assignments shall be as detailed in Appendix 1.

An example of a single interface transceiver circuit is shown in Figure 7.1.2-1 (Ref. ALI-S1002, P.29). All transmitters shall be either a Harris HS-26C31RH or a HS-26CT31RH and all receivers shall be either a Harris HS-26C32RH or a HS-26CT32RH. The receiver inputs shall be AC terminated with a 120 Ohms resistor and a 100 pf capacitor.

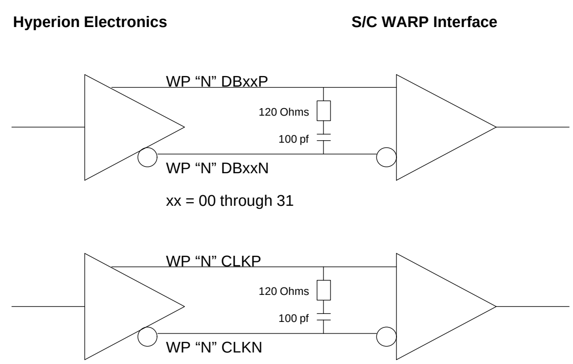


Figure 7.1.2-1 Example Image Data Interface Transceiver Circuit.

7.1.3 Image Data Timing

The two 32-cable RS-422 science data interfaces shall be RS-422 compatible configured with the disconnect state at logic 0 (logic 1 at the receiver output). Associated with each 32-bit data word shall be a gated data clock which controls the strobing of the data into the WARP interface. There shall be no activity (logic 1) on the port clock prior to a data transfer and the port clock shall stop completely after the last read cycle of a data transfer. Detailed data timing shall be as shown in Figure 7.1.3-1.

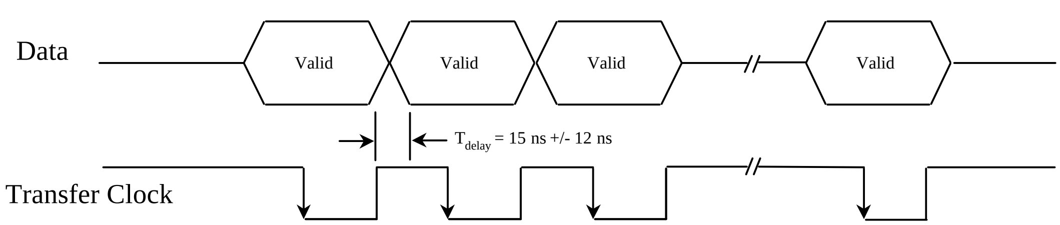


Figure 7.1.3-1 Hyperion Image Data Interface Bit Leveling

7.1.4 Image Data Header

The image data are stored as VNIR frames and SWIR frames. Each frame shall consist of a header followed by the image data. The VNIR frame header shall consist of 4 32-bit words and the SWIR frames header shall consist of 5 32-bit words. Details of the header format shall be as detailed in Appendix 3.

7.1.5 Image Data Format

Each 32-bit science data word shall consist of two 12-bit pixel data words (DB0:11 and DB16:27) and each with a 4-bit header (DB12:15) and (DB28:31). DB11 and DB27 shall be the MSBs of the 12-bit science data and DB0 and DB16 shall be the LSBs. Details of the image data format is given in Appendix 3.

7.1.5.1 VNIR Image Data Format

The Hyperion VNIR Focal Plane Array is fabricated to SSTI/HSI Equipment Specification EQ3-057 "Equipment Specification for the HSI VNIR Focal Plane Array". The VNIR frame rate is 223.4 Hz and matches the SWIR frame rate. The nominal frame rate shall be constant to 0.5 Hz (3 sigma) for 3 minutes. The VNIR frame timing detail is shown in Figure 7.1.5.1-1.

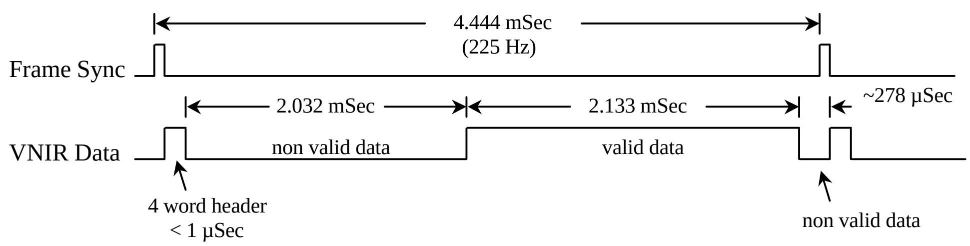


Figure 7.1.5.1-1 Hyperion VNIR Data Frame Timing

The VNIR FPA contains 384 spectral X 768 spatial pixels with a 20 um pitch. The FPA readout is partitioned into 4 quadrants with a separate readout port for each quadrant. The VNIR FPA electronics provide a 3 pixel X 3 pixel aggregation while clocking the data off the FPA. After the pixel aggregation, the FPA has 128 spectral and 256 spatial pixels. Each aggregated pixel data is digitized to a 12-bit data word. 70 contiguous 10 nm spectral bands shall be read out as VNIR science data. 60 spectral bands shall be the requirement signal bands and 10 spectral bands shall be included to facilitate the alignment process. The total VNIR science data volume, frame header included, is 286,848 bits (8964 32-bit words) per frame. The data rate, at 223.4 frames per second, is 64,081,843.2 bits per second (2,002,557.6 32-bit words per second).

7.1.5.2 SWIR Image Data Format

The Hyperion SWIR Focal Plane, FPE and ASP are being fabricated to SSTI/HSI Equipment Specification EQ3-056 "Equipment Specification for the HSI SWIR Focal Plane Array". The SWIR fame rate is 223.4 Hz and matches the VNIR frame rate. The nominal frame rate shall be constant to 0.5 Hz (3 sigma) for up to 3 minute in duration. The SWIR frame timing detail is shown in Figure 7.1.5.2-1.

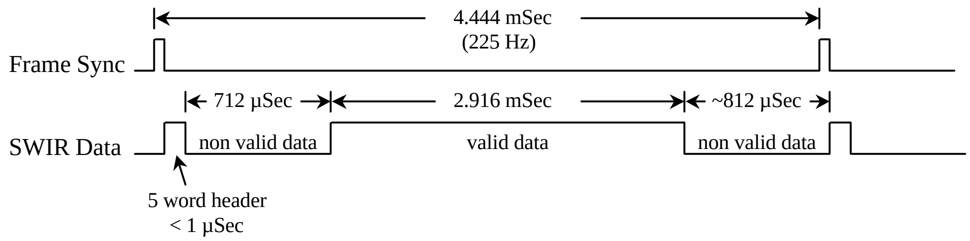


Figure 7.1.5.2-1 Hyperion SWIR Data Frame Timing

The SWIR FPA contains 256 spectral X 256 spatial pixels and the FPA data readout is partitioned into 4 readout ports. Each pixel data is digitized into a 12-bit word. 172 contiguous SWIR 10 nm spectral bands shall be read out as SWIR science data. 160 spectral bands shall be the requirement bands and 12 extra spectral bands shall be read out to facilitate the alignment process. The total data volume is 704,672 bits (22,021 32-bit words) per frame. The data rate, at 223.4 frames per second, is 157,432,724.8 bit per second (4,919,491.4 32-bit words per second).

8. Hyperion Pointing Allocation
8.1 Spacecraft Point Error Budget
8.1.1 Spacecraft Position Knowledge

The spacecraft position knowledge from GPS is 450 m, 3 sigma.

8.1.2 Spacecraft Attitude Knowledge

The spacecraft yaw knowledge is 80 arcsec. The roll error is 80 arcsec, and the pitch error is 100 arcsec.

8.2 Hyperion to Spacecraft Pointing Error Allocation
8.2.1 Hyperion Alignment Cube to Spacecraft Attitude Vector Error Allocation

The Hyperion alignment cube vector to the spacecraft attitude coordinate system error shall be known to less than 16 arcsec in yaw, 10 arcsec in roll, and 10 arcsec in pitch by ground measurements.

Due to gravity release and temperature differences, on-orbit co-alignment measurements will be necessary to reduce errors in the on-orbit alignment between the ACS and Hyperion boresight. The on-orbit alignment measurements determine the Hyperion boresight angle by comparing the image to ground-truth points. The actual pointing angle—as derived from ground-truth points—is then compared to the best-possible, post-processed pointing angle derived from the ACS data. This image-to-ACS co-alignment must be repeated several times to achieve an accurate measurement of the position of the Hyperion boresight with respect to the ACS coordinate system.

8.2.2 Hyperion Boresight to Alignment Cube Error Allocation

The Hyperion boresight knowledge with respect to the alignment cube shall be less than 16 arcsec in yaw, 10 arcsec in roll, and 10 arcsec in pitch, as measured at TRW.

8.2.3 Hyperion Image Data Time Tag Error

The on-ground correction of spacecraft time shall provide spacecraft time "Tone" knowledge to +/- 2 ms (13.5 m), 1 sigma.

The Hyperion shall encode the "Sync Time" (time from spacecraft time "Tone" to hyperion frame sync) in the science data header to +/- 32 µsec (0.2 m), 1 sigma. Details of the Hyperion science data "Time Tag" header timing is shown in Figure 3.3.1-1.

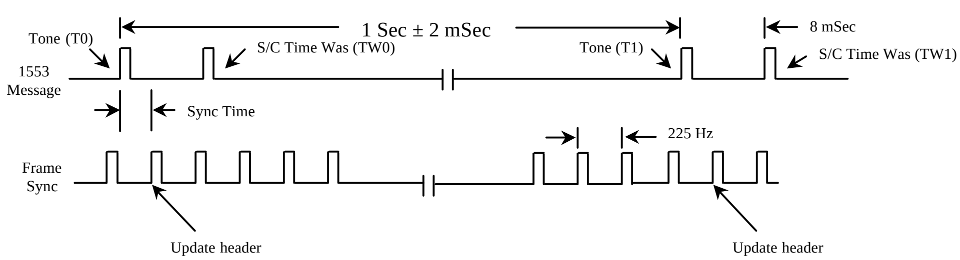
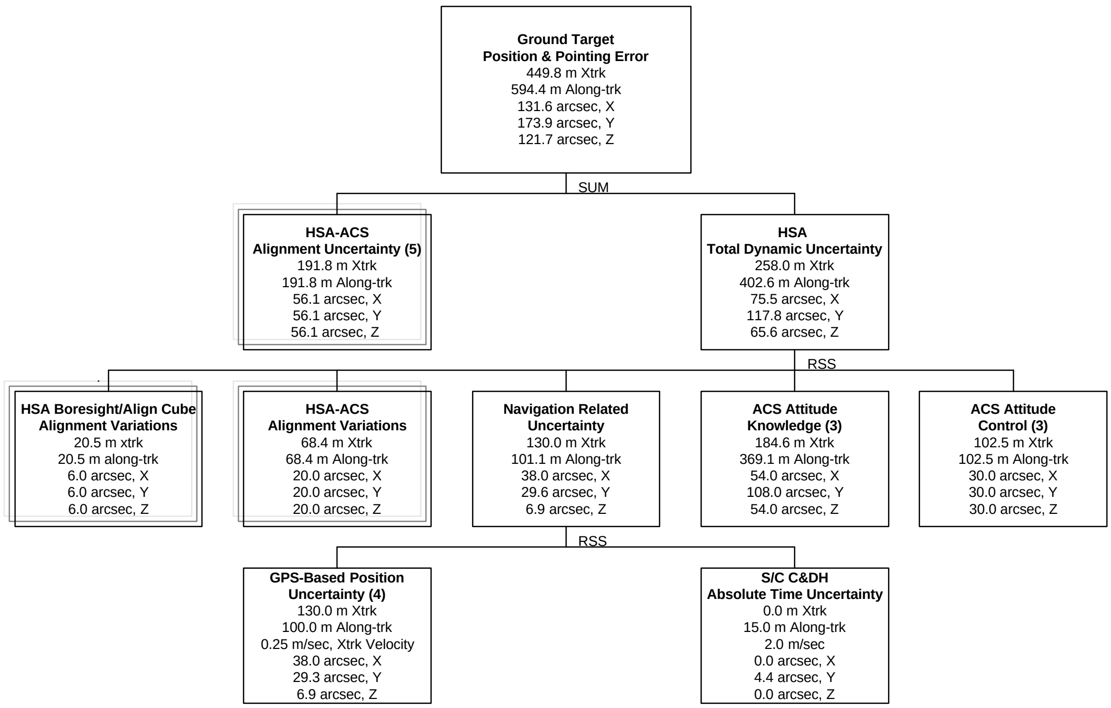


Figure 3.3.1-1 Hyperion Science Data "Time Tag" Timing

8.3 Hyperion Boresight Error Budget

The expected Hyperion image targeting capability (EO-1 Delta CDR, 9/23/98, P.7-54, by Scott Miller and Paul Sanneman) is summarized in Figure3.4-1.



1. All numbers are 3-sigma values.
2. Conversion between angles and meters based on 705 km reference altitude.
3. ACS estimates represent expected EO-1/Hyperion nadir pointing capability and depend significantly on star tracker performance.
4. GPS Uncertainties based on 'Phase 1' results of EO-1 Flight GPS Tensor Test Report (6/22/98).
5. HSA-to-ACS Alignment Uncertainty estimate based on post-processing of ACS altitude (30 arcsec), GPS Navigation data (50 m), and Hyperion image recognition/Processing (45 arcsec or 150 m).
6. This budget doesn't include prediction errors related to development of the absolute time command sequence development which will provide ground commands to ACS and initiate the science observation sequence (1 to 3 days predict).

Figure 3.4-1 Hyperion Pointing Error Budget

9. Thermal Interface
9.1 Description

The HSA is thermally isolated from the spacecraft and is mounted on an instrument platform on the nadir deck. The thermal interface details are specified in the Hyperion drawing #868800-1.

The HEA and the CEA are mounted on an instrument platform on the nadir deck. The units are cooled both conductively through the spacecraft structure and radiatively through one side of each box acting as a radiator

9.2 HSA Thermal Interface

The HSA is thermally isolated from the spacecraft instrument platform (Figure 9.2-1) using G-10 spacers (Figure 9.2-2). The HSA Aluminum honeycomb enclosure provides an isothermal environment to the opto-mechanical subsystem (OMS). The OMS is thermally isolated from the HSA honeycomb enclosure with 4 titanium struts and the OMS temperature is controlled using heaters (Figure 9.2-3).

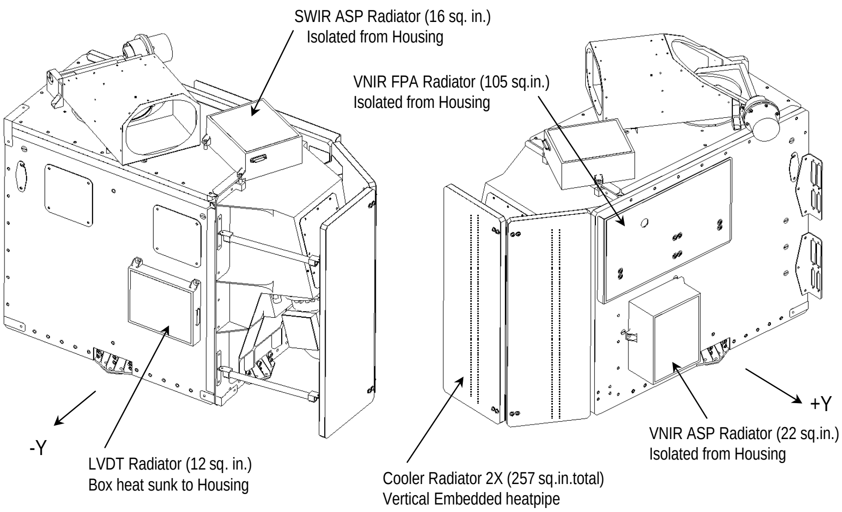


Figure 9.2-1 Locations of the Thermal Radiators on the HSA

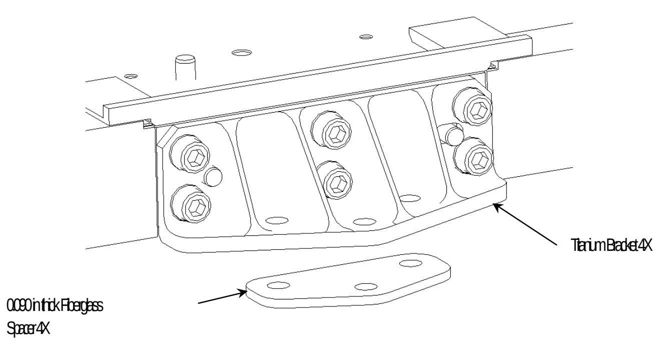


Figure 9.2-2 HSA G-10 Thermal Isolator

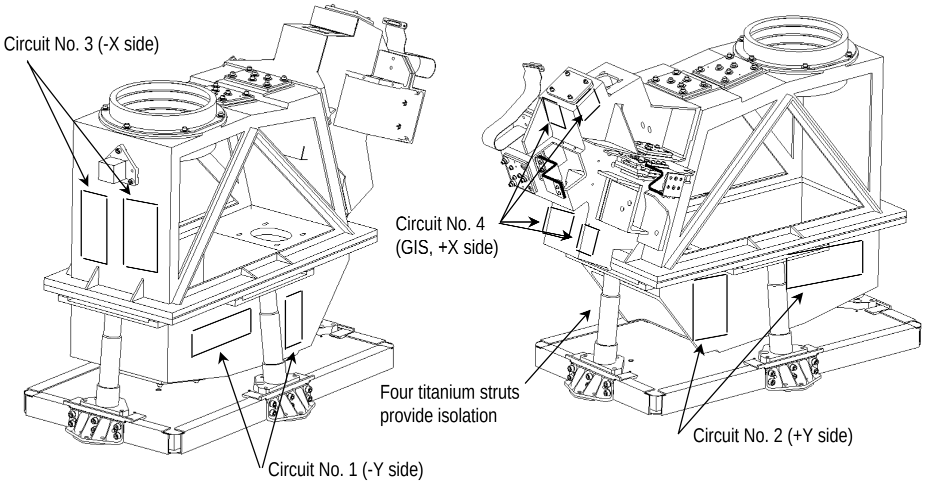


Figure 9.2-3 OMS Temperature Control Heater Locations

Both the VNIR FPA/FPE and the cryocooler pulse tube are supported by the HSA enclosure and have radiators to maintain FPA temperatures at the optimal operation range.

The VNIR ASP and the SWIR ASP are thermally isolated from the HSA enclosure. Temperatures of the ASPs are maintained by radiators.

The detailed thermal design of the HSA and components are shown in Table 9.2.1-1.

Subsystem	Predicted Survival Temp (C) (Capability)	Predicted Operating Temp (C) (Capability)	Radiator Area (in^2)	Subsystem to S/C Thermal Intf (in^2)	Subsystem to S/C Heat Xfer (W)
HSA				Isolated	-7 to +5
Enclosure (LVDT)	-18 (-25)	+9 to +24 (-10 to +40)	12		
Cryocooler	-27 (-40)	+10 to +24 (-10 to +27)	257		
VNIR FPA/FPE	-18 (-25)	-14 to +9 (-10 to +40)	105		
VNIR ASP	-18 (-25)	-8 to +27 (-10 to +40)	22		
SWIR ASP	-18 (-25)	-8 to +38 (-10 to +40)	16		

Table 9.2.1-1 Detailed HSA Thermal Design

9.2.1 HSA Heat Transfer by Conduction and Radiation

The power consumption of the HSA components is detailed in Figure 5.6-1. The conductive heat transfer from the HSA to the nadir deck through the 4 insulating G-10 spacers, at (0.3 Watt/degree) shall be within the -7W (heat flow from Spacecraft to Hyperion) to +5W (heat flow from Hyperion to Spacecraft) range.

The HSA enclosure has a 12 in^2 radiator on the LVDT electronics box and the detailed radiator provisions for the HSA components are shown in Figure 9.2.1-1.

The HSA radiator locations and FOVs are defined in Drawing A0765

9.3 HEA and CEA Thermal Interface

The HEA and CEA are mounted to a plate that is located on the nadir deck of the spacecraft. One side of the each box acts as a radiator. The units also are conductively mounted on an instrument platform with has 6 square inches of contact area with the nadir deck that provides a conductive thermal path to the spacecraft. The spacecraft deck is maintained between 0 and 40 Celsius. The detailed thermal design for the HEA and CEA are shown in Table 9.2.2-1.

Subsystem	Predicted Survival Temp. (C) (Capability)	Predicted Operating Temp. (C) (Capability)	Radiator Area (in^2)	Subsystem to S/C Thermal Interface (in^2)	Subsystem to S/C Heat Xfer (W)
HEA/CEA Assembly				6	3
HEA	TBD (-25)	+12 to +33 (-13 to +39)	76		
CEA	TBD (-25)	+12 to +33 (-10 to +61)	66		

Table 9.2.2-1 Detailed HEA and CEA Thermal Design

9.3.1 HEA and CEA Heat Transfer by Conduction and Radiation

The power consumption of the HEA and CEA are detailed in Figure 5.6-1. The conductive heat transfer from the HEA and CEA to the nadir deck, through the instrument platform, shall be less than 3W.

The HEA and CEA radiator dimensions are shown in Figure 9.2.2-1.

The HEA and CEA radiator locations are defined in Drawing 868800-1.

9.4 Surface Treatment and Restrictions

All exterior surfaces of the Hyperion instrument shall be covered with Aluminized MLI except for area specified in drawing 868800. The Hyperion to spacecraft MLI interface shall be as specified in drawing 868800. TRW shall supply the MLI for the Hyperion components.

All exterior surfaces of the EO-1 spacecraft and payloads shall be covered with Aluminized MLI except for thermal radiators, RF antennas, optical boresight, thruster exhaust tubes, and solar cells.

9.5 Thermal Model and Analysis

Once the Hyperion thermal design is complete, TRW shall supply an accurate thermal model to Swales Aerospace for confirmation of the thermal interfaces and to assess the impact on the satellite thermal control.

10. Electromagnetic Compatibility

The Hyperion shall meet the electromagnetic compatibility requirements per AM-149-0020(155), "System Level Electrical Requirements, EO-1".

10.3 Electronics Discharge Control

The Hyperion instrument shall be protected from electrostatic discharge by providing proper grounding of the instrument and of personnel to prevent static charge built-up. No static sensitive circuit connectors will be de-mated/mated or uncovered while the relative humidity is less than 20%.

All layers of all MLI on the Hyperion instrument shall be grounded to the spacecraft.

11. Potential Hazards

The Hyperion Instrument has no potential hazards as defined in the SSTI Safety Assessment Report (D22886).

12. Hyperion Test Interfaces

The Hyperion Integration and Test Plan contains all the specific test levels, the functional and performance tests conducted at each phase of testing, and the equipment and facilities required for the tests. Test data shall be delivered with Hyperion so that the test and operating teams can evaluate Hyperion health during test and operations.

12.1 Design Requirements
12.1.1 Minimum Natural Frequencies

The minimum natural frequency for the HSA shall be greater than 70 Hz in any direction at the unit mass of 35 kg. The HEA and the CEA minimum natural frequency shall be greater than 100 Hz in any direction.

12.1.2 Design Environments
12.1.2.1 Limit Loads

The EO-1 will be launched with a Delta II Med-Lite 7320-10 launch vehicle. The Hyperion instrument shall be designed for the environment specified in SAI-SPEC-158 “EO-1 Verification Plan and Environmental Specification”. The Hyperion shall be designed to withstand 1.25 times the quasi-static loads shown in Table 12.1.2.1-1a, b acting at the center of gravity of the instrument.

Table 12.1.2.1-1a Flight Limit Loads Factors for the HSA

Case 1	4.1 g axial compression + 11.0 g in any lateral direction
Case 2	1.0 g axial tension + 11.0 g in any lateral direction
Case 3	7.9 g axial compression + 0.1 g in any lateral direction
Note: 1. Axial direction is parallel to the EO-1 satellite Z-axis 2. The axial and lateral limit load factors are to be applied simultaneously 3. Compression is the acceleration sense that produces compression at the spacecraft interface	

Table 12.1.2.1-1a Flight Limit Loads Factors for the HEA and the CEA

Case 1	15 g in any direction

12.1.2.2 Factor of Safety

The following factor of safety shall be applied to the design loads to derive yield and ultimate stresses:

Protoflight test limits

Yield	1.25 x
Ultimate Stress	1.4 x

No-test limits

Yield	2.0 x
Ultimate Stress	2.6 x

12.2 Pre-Delivery Test Requirements
12.2.1 General Test Requirements

The Hyperion environmental test requirements are summarized in Table 12.2.1-1 and the test levels are summarized in Table 12.2.1-2.

Table 12.2.1-1 Hyperion Environmental Test Requirements

	Sine Burst	Sine Vibration	Random Vibration	Shock	Thermal Vacuum	Thermal Balance	Thermal Cycle	EMI/EMC
Instrument		Yes	Yes		Yes	Yes	Yes	Yes

Table 12.2.1-2 Hyperion Environmental Test Levels

Sine Vibration	Random Vibration	Thermal Vacuum	Thermal Cycles
1.25 x flight level	flight level + 3 dB	predicted flight level hot +10C & cold - 10C	predicted flight level hot +15C & cold - 15C

12.2.2 Vibration Tests

Hyperion shall be in the survival mode (only the heater service is powered) during vibration testing. The integration and test plan shall define the functional and performance tests conducted before, during, and after vibration testing.

12.2.2.1 Sinusoidal Vibration

Per SAI-SPEC-158, P. 46, Hyperion sweep rate (protoflight) shall be 1.25X estimated flight level vibration amplitudes. table 12.2.2-1 listed the vibration levels and parameters for the HSA, HEA and CEA assemblies.

Table 12.2.1-3 Hyperion Sinusoidal Vibration Test Levels (1.25 x Flight Levels)

X and Y axes		
Frequency	Magnitude	Duration
5 - f(x,y) Hz	0.5- inch D.A.	4 Octave/min.
f(x,y) - 25 Hz	A	4 Octave/min.
25 - 35 Hz	A	1.5 Octave/min.
35 - 50 Hz	A	4 Octave/min.

Z axis		
Frequency	Magnitude	Duration
5 - f(z) Hz	0.5 inch D.A.	4 Octave/min.
f(z) - 25 Hz	B	4 Octave/min.
25 - 35 Hz	B	1.5 Octave/min.
35 - 50 Hz	B	4 Octave/min.

	A	f(x,y)	B	f(z)
HSA	TBD	TBD	TBD	TBD
HEA	TBD	TBD	TBD	TBD
CEA	TBD	TBD	TBD	TBD

12.2.2.2 Random Vibration

Table 12.2.2.2-1a and b are the Hyperion Random Vibration test levels. The test levels may be reduced (notched) in specific frequency bands with Project concurrence. The test levels shall be applied at the interface with the spacecraft. The test duration shall be 1 min./axis for each of 3 orthogonal axes and one of which shall be normal to the mounting surface.

Table 12.2.2.2-1a Random Vibration Test Levels for the Hyperion HSA

Frequency	Magnitude
20 Hz	0.0129 g2/Hz
20 - 40 Hz	+6 dB/Octave
40 - 1000 Hz	0.080 g2/Hz
1000 - 2000 Hz	-4 dB/Octave
2000 Hz	0.0127 g2/Hz
Overall	9.0 grms

Table 12.2.2.2-1b Random Vibration Test Levels for the Hyperion HEA and CEA

Frequency	Magnitude
20 Hz	0.026 g2/Hz
20 - 50 Hz	+6 dB/Octave
50 -800 Hz	0.16 g2/Hz
800 - 2000 Hz	-6 dB/Octave
2000 Hz	0.026 g2/Hz
Overall	14.1 grms

12.2.3 Thermal Cycles Tests at Ambient

The ambient thermal cycle tests for the HEA and CEA shall consist of 1 thermal cycle at the survival temperatures and 1 thermal cycle at the temperature limits per Table 12.2.1-2. The Hyperion instrument shall be operating during the thermal cycle at the operating temperatures. The Hyperion instrument survival and operating temperatures are listed in Table 9.2.1-1 and 9.2.2-1.

12.2.4 Thermal Vacuum Tests

The thermal vacuum tests for the Hyperion instrument consists of one (1) cycle at the survival temperatures, and seven (7) thermal cycles at the temperature limits per Table 12.2.1-2. In addition, a thermal balance test and a vacuum performance verification test shall be conducted at the nominal instrument operating temperatures.

12.2.5 EMI/EMC Testing

The Hyperion shall meet the electromagnetic compatibility requirements per AM-149-0020(155), "System Level Electrical Requirements, EO-1". The Hyperion instrument shall be tested per the procedures of MIL-STD-462 according to the requirement of MIL-STD-461C as amended by AM-149-0020(155).

The specific MIL-STD-461C test requirements are (1) Conducted Emissions including CE01, CE03, CE06, and CE07; (2) Conducted Susceptibility including CS01, CS02, CS03, CS04, CS05, and CS06; and (3) Radiated Emissions including RE01, RE02, and RE03. The Test Methods and Test Limits specifications are detailed in AM149-0020(155) P.34.

12.2.6 Functional and Performance Testing

TRW will develop a functional test procedure to demonstrate all instrument functional requirements including processing of commands and telemetry over the 1773 interface and the collection and transmission of science data over the 32-wire RS-422 interface.

TRW will develop a performance test procedure to measure the instrument performance requirements in the Hyperion Instrument Specification, EQ7-0459.

12.3 Hyperion Instrument Acceptance Test at GSFC
12.3.1 Instrument Acceptance Tests

Upon delivery of the Hyperion instrument to GSFC, TRW shall conduct a post-ship bench acceptance test on the Hyperion at GSFC. The acceptance tests shall be an abbreviated version of the Hyperion Functional Test Procedure #TBD. GSFC shall provide Class 100,000 or better clean room facility for the acceptance tests. Figure 12.2.7.1 shows the Hyperion Instrument Acceptance Test Configuration.

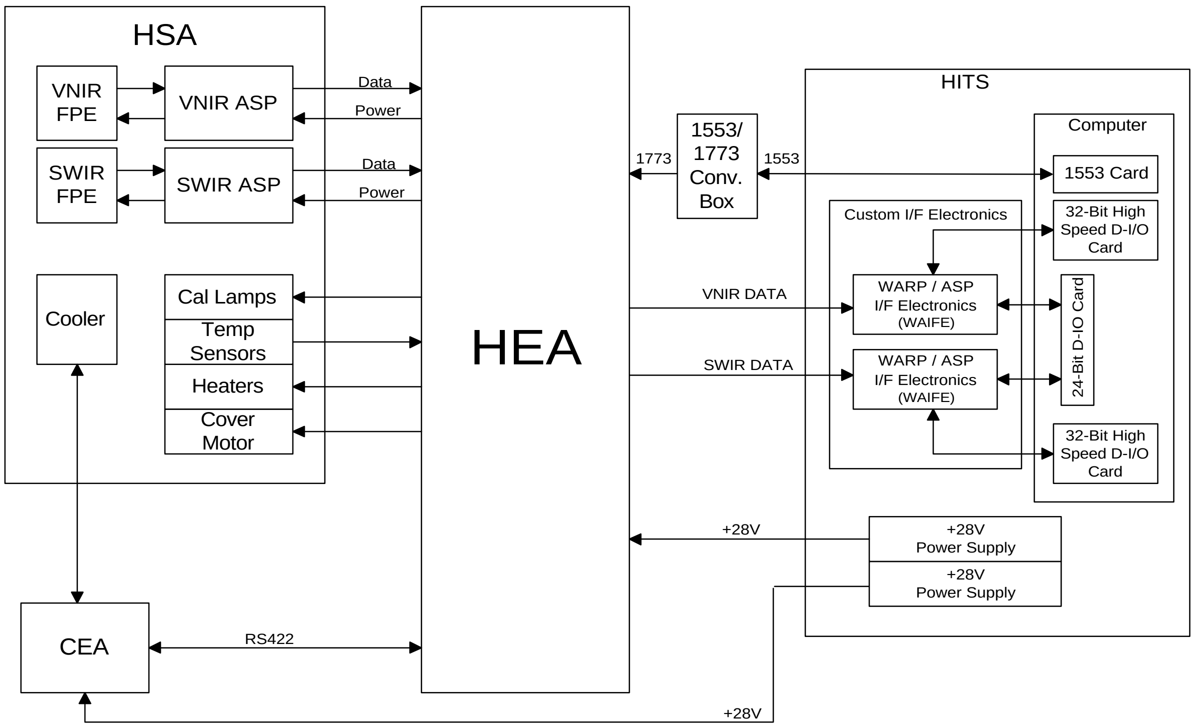


Figure 12.2.7.1-1 Hyperion Instrument Acceptance Test Configuration

12.3.2 Hyperion Instrument TestSet (HITS)

TRW shall provide a testset to support the above acceptance tests. This testset shall be capable of commanding the Hyperion, and shall be capable of collecting, displaying and storing instrument telemetry and science data for verification of instrument functions and performance.

12.4 Post Spacecraft Installation Hyperion Instrument Tests
12.4.1 Post Spacecraft Installation Functional Test

After the installation of the Hyperion on the spacecraft, Hyperion Instrument Functional Test shall be the responsibility of GSFC. A conceptual Hyperion Spacecraft Test Configuration is shown in Figure 12.2.8.1-1. TRW shall provide the necessary 1773 commands for the functional tests and the spacecraft contractor shall encode the 1773 commands into ASIST STOL. TRW Hyperion spacecraft test support at GSFC, including software and test data analysis support, is not planned and can be provided as an option.

12.5 Operating Time

An operating time record of the Hyperion Instrument shall be kept. The time record shall include the operating time for the aperture motor, the calibration lamps, the cryocooler pulse tube and the electronics assemblies.

An operating time record of the Hyperion Instrument shall be kept. The time record shall include the operating time for the aperture motor, the calibration lamps, the cryocooler pulse tube and the electronics assemblies.

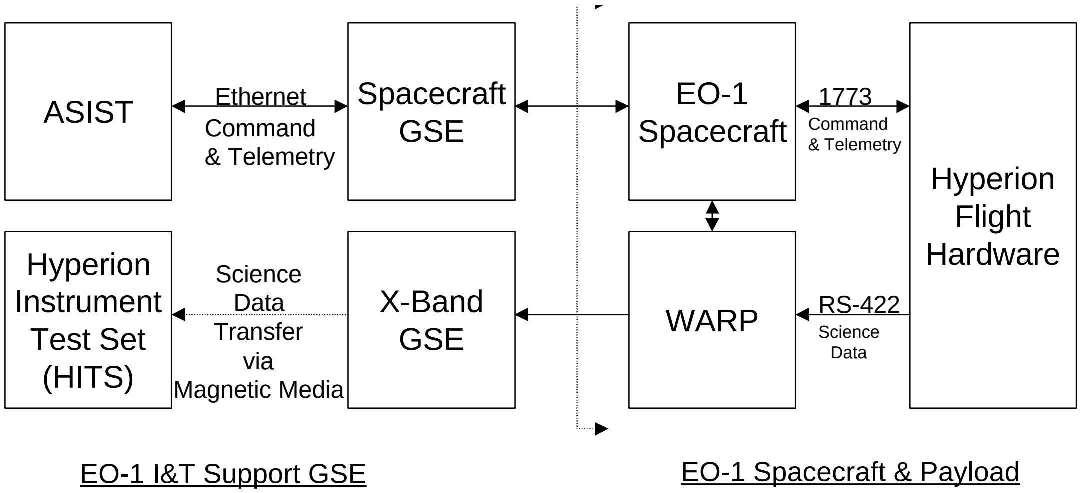


Figure 12.2.8.1-1 Hyperion Spacecraft Integration and Test configuration.

13. Contamination and Cleanliness

13.1 As-Delivered Contamination Requirement

The Hyperion Instrument will conform to a cleanliness level standard of 500A per MIL-STD-1246B. The instrument contamination control during integration shall conform to the SSTI procedure D22893.

13.2 Storage and Transportation Environment

The Hyperion Instrument storage and transportation environment shall SAI-SPEC-158, "EO-1 Verification Plan and Environmental Specification" and the SSTI procedure D22893. The Hyperion assemblies shall be bagged, purged and backfilled with filtered, dry, semiconductor grade nitrogen (99.995% pure, water content <1 ppm) at all times during storage and transportation.

13.3 Integration and Test Facility Environment

The Hyperion integration and test facility environment shall conform to the EO-1 Environmental Specification and the SSTI D22893. The Hyperion Instrument shall remain bagged and purged with filtered, dry, semiconductor grade nitrogen (99.995% pure, water content <1 ppm) during integration on the spacecraft except when it is necessary to make required electrical connections.

14. Spacecraft Integration and Launch Site Requirements
14.1 Hyperion Operating Constraints During Spacecraft Integration

The following constraints on the Hyperion testing and operation shall be satisfied after its integration onto the spacecraft prior to on-orbit operation. Additional information and detail is in the Hyperion Integration and Test Plan.

1. The Hyperion instrument aperture cover shall normally be closed during spacecraft integration. Aperture cover tests may be conducted inside the HSA protective bag if adequate clearance is established. Aperture cover open time must be minimized and logged. Any inadvertent opening of the aperture cover when the HSA is not bagged shall be reported immediately to TRW.
2. The SWIR focal plane shall not be cooled below 10C at ambient pressure. This will curtail the operation of the SWIR FPA since it will not function properly at ambient temperature.
3. Operation of the in-flight calibration lamp sources in the HSA shall be monitored during I&T to prevent an over-temperature condition.
4. The HSA shall remain bagged at all times and shall be purge/backfill with filtered, dry, semiconductor grade nitrogen (99.995% pure, water content <1 ppm).
5. The number of calibration lamp cycles shall be minimized and logged. The cumulative calibration lamp operation time shall not exceed 10 minutes during satellite I&T.
6. The interior surface of the aperture cover shall not be touched to avoid damage to the sensitive calibration painted surface.

14.2 Integration and Test Facilities Contamination Level

The Hyperion to spacecraft integration shall take place in a Class 100,000 environment. A Class 10,000 tent or hood shall be used in the event the optical surface of the Hyperion instrument is exposed.

14.4 **Ground Support Equipment**
14.4.1 **Mechanical GSE**

The Hyperion HSA shall have lifting points per the interface control drawing #868800-1. The mechanical GSE (MGSE) for lifting and installation of the HSA shall be provided by TRW. The HEA and the CEA can be hand carried and requires no lift points.

14.4.2 Electrical GSE

With the exception of the HITS, all electrical GSE (EGSE) shall be provided by GSFC to support Hyperion/Spacecraft integration and test per Figure 12.2.8.1-1. If GSFC elect to perform test procedure verification prior to Hyperion delivery, GSFC shall also provide test and characterization hardware for the 1773 interface, and an ASIST system.

14.5 Transportation, Handling, and Storage

The Hyperion instrument shall be protected during handling, transportation, storage, and other pre-launch activities per the SSTI/HSI Contamination Control Plan (D22893).

14.5.1 Transportation Requirements

The Hyperion instrument shall be bagged and dry gas purged before transportation outside of controlled environment. The shipping container interior material and padding shall not generate particulate contamination and shall be cleaned prior to packing Hyperion to MIL-STD-1246B, level 500 per SSTI Contamination Plan (D22893). All Hyperion assemblies shall remain bagged during transportation. The shipping container shall be instrumented to record maximum accelerations in all three axes as specified (TBD).

14.5.2 Handling Restrictions

The HSA handling fixture shall be used at all times and the radiator surfaces shall not be touched during handling operations.

14.5.3 Storage Requirements

The Hyperion assemblies shall remain bagged during period of storage. A dry nitrogen purge shall be provided during storage periods which are longer than 12 hours.

14.6 Satellite Environmental Tests

After delivery to GSFC, Hyperion will be mounted to the satellite and undergo the following environmental tests as part of the completed satellite:

- Acoustic
- Shock
- Thermal balance
- Thermal vacuum

Complete detail on these tests is contained in the Delta CDR presentations and in Revision D of the EO-1 Integration and Test Plan.

14.7 Models for Satellite Environmental Test

TRW shall supply a structural model of the HSA to be used during spacecraft vibration tests.

14.8 Safety Documentation

TRW shall supply safety information to Swales Aerospace. This includes information required by the launch vehicle and launch site concerning the cryogenic pressure vessel.

15. Operational Requirements
15.1 Spacecraft Operation Constraints

The Hyperion instrument imposes the following constraints on the spacecraft operational modes:

1. Survival heater power shall be continuously provided to Hyperion, including during launch.
2. The instrument survival mode shall be used only in anomalous conditions.
3. The Cryocooler flange shall be kept above -10C for start-up and during operation.
4. When the Hyperion instrument aperture cover is opened, operators shall restrict the sun position per the drawing 868800 to avoid damage to the FPAs.
5. After launch, Hyperion will remain in the survival mode for one to two weeks, until the operations team completes initial checkout of the spacecraft systems.

15.2 Hyperion Instrument Operational Modes

Upon application of HEA and CEA power, the Hyperion instrument will boot up and enter the Idle Mode. When HEA and CEA power is removed, Hyperion will be in the Off Mode or Survival mode, depending on whether the heater power is switched on.

15.2.1 Off Mode

In the Off Mode, all internal power, including the heaters, of the Hyperion is off and the aperture cover should have been secured. This mode will not be used on orbit.

When power is applied to the HEA, the unit will self boot and enter the idle mode. When power is applied to the CEA, the unit will also self boot. After the CEA processor is booted up command and telemetry capabilities between the CEA and the HEA will be established.

15.2.2 Idle Mode

In the Idle Mode, the instrument aperture cover is closed, the control processor is alive, heaters are operational, the cryocooler temperature is regulated, telemetry data is being collected, and the 1773 interface is alive to support instrument/spacecraft command and telemetry.

15.2.3 Standby Mode

In the Standby Mode, all components of the instrument are functional with the exception that no science data is transmitted to the spacecraft WARP

15.2.4 Imaging Mode

In the Imaging Mode, all components of the instrument are powered. The FPA data are clocked out to the ASPs, the data formatter, and transmitted to the spacecraft WARP. Collection of earth imaging (science) data and solar calibration data are controlled by spacecraft pointing. Dark calibration or “zero” data is collected with the aperture closed. In-flight calibration data with the calibration lamp is taken with the aperture cover closed and the calibration lamp powered.

The operation of the ASPs shall not exceed 15 minutes to avoid over-heating.

15.2.5 Survival Mode

In the Survival Mode, the instrument aperture cover should have been closed, power is removed from the HEA and the CEA, and instrument command and telemetry capabilities are dropped. The HSA temperatures, including the cryocooler pulse tube, the VNIR FPA and the SWIR FPA, are maintained by thermostat controlled heaters.

15.2.6 Orbital Instrument Operation Sequence for Image Data

A typical on-orbit image data collection operation for the Hyperion instrument consists of the following steps:

Standby/Warm-up	10 minutes
Dark Calibration	1 second
Aperture Open	15 seconds
Imaging Mode	27 seconds
Aperture Close	15 seconds
Dark Calibration	1 second
Lamp Calibration	45 seconds
Total	**11 minutes and 44 seconds**

15.3 Health and Safety

The spacecraft shall monitor several critical telemetry parameters and take appropriate action if the values exceed predetermined limits. TRW shall work with Swales Aerospace to specify the telemetry points, the limits, and the designated actions.

Following a reset or power-on, Hyperion shall issue commands to protect the instrument, including a close-door command and ASP-off commands.

If the spacecraft main processor is functioning and communicating with Hyperion, it will issue commands to safe the instrument before turning off power.

Appendix 1. Hyperion Connector Specifications and Pin Assignments

A1.1 Hyperion 28 VDC Power Connector and Pin Assignments
A1.1.1 28 VDC Power Connector Specification

(Note: to build the connectors, we will need wire drawings with pair/twist requirements, etc. But that information can be separate from this ICD.)

The Hyperion HEA shall have one (1) 28 VDC power connector and the connector shall be a 9-pin pin-type D-connector. The Hyperion CEA shall have one (1) 28 VDC power connector and the connector shall be a 9-pin pin-type D-connector.

A1.1.2 HEA 28 VDC Connector Pin Assignments

The HEA 28 VDC connector pin assignment shall be as specified in Table A1.1.2-1.

Table A1.1.2-1 HEA J101-9P Connector Pin Assignment

Pin #	Signal Name	Description
1	+28V	+28V Bus
2	+28V	+28V Bus
3	+28VH	+28V Heater Bus
4	+28VH	+28V Heater Bus
5	CGND	Chasis Ground
6	28V RTN	+28V Bus Return
7	28V RTN	+28V Bus Return
8	28VH RTN	+28V Heater Bus Return
9	28VH RTN	+28V Heater Bus Return

A1.1.3 CEA 28 VDC Connector Pin Assignments

The CEA 28 VDC connector pin assignment shall be as specified in Table A1.1.3-1. The CEA 28 VDC power lines shall be common with the HEA 28 VDC power lines.

Table A1.1.3-1 CEA J101-9P Connector Pin Assignment

Pin #	Signal Name	Description
1	CHGND	Chasis ground
2	PWRA+	+28V A Bus (Common with HEA J101-1,2)
3	PWRA+	+28V A Bus (Common with HEA J101-1,2)
4	PWRB-	
5	PWRB-	
6	PWRB+	
7	PWRB+	
8	PWRA-	+28V A Bus Return (Common with HEA J101-6,7)
9	PWRA-	+28V A Bus Return (Common with HEA J101-6,7)

A1.1.4 HSA Temperature Monitor Connector Pin Assignment

The HSA shall have four (4) temperature sensors (YSI 44905 thermistors, GSFC S311P18-05A76R, 5K Ohms at 25C) routed to a 9-pin pin-type D-connector for monitoring by the spacecraft. The pin assignments for the 9-pin pin-type D-connector is as shown in Table A1.1.4-1.

Table A1.1.4-1 HSA Temperature Monitor 9-pin D-connector Pin Assignments

Pin #	Signal Name	Description
1	TEMP_1+	OMS temperature
2	TEMP_2+	Cryocooler flange temperature
3	TEMP_3+	VNIR ASP temperature
4	TEMP_4+	SWIR ASP temperature
5	GND	
6	TEMP_1-	OMS temperature return
7	TEMP_2-	Cryocooler flange temperature return
8	TEMP_3-	VNIR ASP temperature return
9	TEMP_4-	SWIR ASP temperature return

A1.2 32-wire RS-422 Interface Connector Specification and Pin Assignments

A1.2.1 32-wire RS-422 Interface Connector Specification

The Hyperion VNIR and SWIR 32-wire RS-422 science data bus shall use a 78-pin socket-type D-connector.

A1.2.2 32-wire RS-422 Interface Connector Pin Assignments

The pin assignments for the SWIR and the VNIR image data shall be as specified in Figure A1.2.2-1 and A1.2.2-2 respectively.

Figure A1.2.2-1 VNIR Image Data 32-wire RS-422 Interface Connector J110-78S Pin Assignment

Pin #	Signal Name	Description
1	WVDAT00H	Data bit 0 - positive
20	NC	no connect
21	WVDATA00L	Data bit 0 - negative
2	WVDATA01H	Data bit 1 - positive
22	WVDATA01L	Data bit 1 - negative
3	WVDATA02H	Data bit 2 - positive
23	WVDATA02L	Data bit 2 - negative
4	WVDATA03H	Data bit 3 - positive
24	WVDATA03L	Data bit 3 - negative
5	WVDATA04H	Data bit 4 - positive
25	WVDATA04L	Data bit 4 - negative
6	WVDATA05H	Data bit 5 - positive
26	WVDATA05L	Data bit 5 - negative
7	WVDATA06H	Data bit 6 - positive
27	WVDATA06L	Data bit 6 - negative
8	WVDATA07H	Data bit 7 - positive
28	WVDATA07L	Data bit 7 - negative
9	WVDATA08H	Data bit 8 - positive
29	WVDATA08L	Data bit 8 - negative
10	WVDATA09H	Data bit 9 - positive
30	WVDATA09L	Data bit 9 - negative
11	WVDATA10H	Data bit 10 - positive
31	WVDATA10L	Data bit 10 - negative
12	WVDATA11H	Data bit 11 - positive
32	WVDATA11L	Data bit 11 - negative
13	WVDATA12H	Data bit 12 - positive
33	WVDATA12L	Data bit 12 - negative
14	WVDATA13H	Data bit 13 - positive
34	WVDATA13L	Data bit 13 - negative
15	WVDATA14H	Data bit 14 - positive
35	WVDATA14L	Data bit 14 - negative
16	WVDATA15H	Data bit 15 - positive
36	WVDATA15L	Data bit 15 - negative
17	WVDATA16H	Data bit 16 - positive
37	WVDATA16L	Data bit 16 - negative
18	WVDATA17H	Data bit 17 - positive
38	WVDATA17L	Data bit 17 - negative
19	WVDATA18H	Data bit 18 - positive

39	WVDATA18L	Data bit 18 - negative
40	NC	no connect
41	NC	no connect
42	NC	no connect
43	NC	no connect
44	NC	no connect
45	WVDATA19H	Data bit 19 - positive
65	WVDATA19L	Data bit 19 - negative
46	WVDATA20H	Data bit 20 - positive
66	WVDATA20L	Data bit 20 - negative
47	WVDATA21H	Data bit 21 - positive
67	WVDATA21L	Data bit 21 - negative
48	WVDATA22H	Data bit 22 - positive
68	WVDATA22L	Data bit 22 - negative
49	WVDATA23H	Data bit 23 - positive
69	WVDATA23L	Data bit 23 - negative
50	WVDATA24H	Data bit 24 - positive
70	WVDATA24L	Data bit 24 - negative
51	WVDATA25H	Data bit 25 - positive
71	WVDATA25L	Data bit 25 - negative
52	WVDATA26H	Data bit 26 - positive
72	WVDATA26L	Data bit 26 - negative
53	WVDATA27H	Data bit 27 - positive
73	WVDATA27L	Data bit 27 - negative
54	WVDATA28H	Data bit 28 - positive
74	WVDATA28L	Data bit 28 - negative
55	WVDATA29H	Data bit 29 - positive
75	WVDATA29L	Data bit 29 - negative
56	WVDATA30H	Data bit 30 - positive
76	WVDATA30L	Data bit 30 - negative
57	WVDATA31H	Data bit 31 - positive
58	NC	no connect
59	NC	no connect
60	NC	no connect
63	NC	no connect
64	NC	no connect
77	WVDATA31L	Data bit 31 - negative
78	NC	no connect
61	WVCLKH	Port Clock - positive
62	WVCLKL	Port Clock - negative

Figure A1.2.2-2 SWIR Image Data 32-wire RS-422 Interface Connector J111-78S Pin Assignment

Pin #	Signal Name	Description
1	WSDAT00H	Data bit 0 - positive
20	NC	no connect
21	WSDATA00L	Data bit 0 - negative
2	WSDATA01H	Data bit 1 - positive
22	WSDATA01L	Data bit 1 - negative
3	WSDATA02H	Data bit 2 - positive
23	WSDATA02L	Data bit 2 - negative

4	WSDATA03H	Data bit 3 - positive
24	WSDATA03L	Data bit 3 - negative
5	WSDATA04H	Data bit 4 - positive
25	WSDATA04L	Data bit 4 - negative
6	WSDATA05H	Data bit 5 - positive
26	WSDATA05L	Data bit 5 - negative
7	WSDATA06H	Data bit 6 - positive
27	WSDATA06L	Data bit 6 - negative
8	WSDATA07H	Data bit 7 - positive
28	WSDATA07L	Data bit 7 - negative
9	WSDATA08H	Data bit 8 - positive
29	WSDATA08L	Data bit 8 - negative
10	WSDATA09H	Data bit 9 - positive
30	WSDATA09L	Data bit 9 - negative
11	WSDATA10H	Data bit 10 - positive
31	WSDATA10L	Data bit 10 - negative
12	WSDATA11H	Data bit 11 - positive
32	WSDATA11L	Data bit 11 - negative
13	WSDATA12H	Data bit 12 - positive
33	WSDATA12L	Data bit 12 - negative
14	WSDATA13H	Data bit 13 - positive
34	WSDATA13L	Data bit 13 - negative
15	WSDATA14H	Data bit 14 - positive
35	WSDATA14L	Data bit 14 - negative
16	WSDATA15H	Data bit 15 - positive
36	WSDATA15L	Data bit 15 - negative
17	WSDATA16H	Data bit 16 - positive
37	WSDATA16L	Data bit 16 - negative
18	WSDATA17H	Data bit 17 - positive
38	WSDATA17L	Data bit 17 - negative
19	WSDATA18H	Data bit 18 - positive
39	WSDATA18L	Data bit 18 - negative
40	NC	no connect
41	NC	no connect
42	NC	no connect
43	NC	no connect
44	NC	no connect
45	WSDATA19H	Data bit 19 - positive
65	WSDATA19L	Data bit 19 - negative
46	WSDATA20H	Data bit 20 - positive
66	WSDATA20L	Data bit 20 - negative
47	WSDATA21H	Data bit 21 - positive
67	WSDATA21L	Data bit 21 - negative
48	WSDATA22H	Data bit 22 - positive
68	WSDATA22L	Data bit 22 - negative
49	WSDATA23H	Data bit 23 - positive
69	WSDATA23L	Data bit 23 - negative
50	WSDATA24H	Data bit 24 - positive
70	WSDATA24L	Data bit 24 - negative
51	WSDATA25H	Data bit 25 - positive
71	WSDATA25L	Data bit 25 - negative

52	WSDATA26H	Data bit 26 - positive
72	WSDATA26L	Data bit 26 - negative
53	WSDATA27H	Data bit 27 - positive
73	WSDATA27L	Data bit 27 - negative
54	WSDATA28H	Data bit 28 - positive
74	WSDATA28L	Data bit 28 - negative
55	WSDATA29H	Data bit 29 - positive
75	WSDATA29L	Data bit 29 - negative
56	WSDATA30H	Data bit 30 - positive
76	WSDATA30L	Data bit 30 - negative
57	WSDATA31H	Data bit 31 - positive
58	NC	no connect
59	NC	no connect
60	NC	no connect
63	NC	no connect
64	NC	no connect
77	WSDATA31L	Data bit 31 - negative
78	NC	no connect
61	WSCLKH	Port Clock - positive
62	WSCLKL	Port Clock - negative

Appendix 2. Hyperion Command and Telemetry

A2.1 Command Packet Header

Command Packet Header

Most Significant Bits   Least Significant Bits

Description	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet header 1	Version Number			Type	Sec. Header	Application Process ID										
Packet header 2	Segment Flags		Source Sequence Count													
Packet header 3	Packet Length															
Secondary Header	Reserve	Function Code							Exclusive OR Checksum							

Time Code Distribution

"Tone message:"
Broadcast Subaddress 29

Most Significant Bits   Least Significant Bits

Description	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet header 1	Version Number			Type	Sec. Header	Application Process ID										
Packet header 2	Segment Flags		Source Sequence Count													
Packet header 3	Packet Length															
Secondary Header	Reserve	Function Code							Exclusive OR Checksum							

"At the tone the time was:"
Broadcast Subaddress 28

Most Significant Bits   Least Significant Bits

Description	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet header 1	Version Number			Type	Sec. Header	Application Process ID										
Packet header 2	Segment Flags		Source Sequence Count													
Packet header 3	Packet Length															
Secondary Header	Reserve	Function Code							Exclusive OR Checksum							
Data Word 1	Sequence Counter															
Data Word 2	Time code: Most Significant Word															
Data Word 3																
Data Word 4																
Data Word 5	Time code: Least Significant Word															

Wrap Around Data
Transmit Subaddress 30

A2.2 Instrument Command List

		MSB			LSB
Mne- monic	Command	15 12	1 8	7 4	3 0
1NOOP	No operation	0	0	0	0
1NVPAR	Set VNIR Params	0	1	0	2
		0			VNIR Offset A
		0			VNIR Offset B
		0			VNIR Offset C
		0			VNIR Offset D
1SWPAR	Set SWIR Params	0	1	0	3
		0			Gain A
		0			Gain B
		0			Gain C
		0			Gain D
		0		Offset A	
		0		Offset B	
		0		Offset C	
		0		Offset D	
		0		Integration Time	
1OPCVR	Cover Open	0	2	0	1
1CLCVR	Cover Close	0	2	0	2
1SCCVR	Cover to Solar Cal	0	2	0	3
1CL1LV	Set Prim. Lamp Level	0	3	0	1
		0		Primary Lamp Level (0-255)	
1CL2LV	Set Sec. Lamp Level	0	3	0	2
		0		Secondary Lamp Level (0-255)	
1STHTR	Set Heater Setpoints	0	4	0	1
		0	Heater 1 Minimum Temp		
		0	Heater 1 Maximum Temp		
		0	Heater 2 Minimum Temp		
		0	Heater 2 Maximum Temp		
		0	Heater 3 Minimum Temp		
		0	Heater 3 Maximum Temp		
		0	Heater 4 Minimum Temp		
		0	Heater 4 Maximum Temp		
		0	Heater 5 Minimum Temp		
		0	Heater 5 Maximum Temp		
		0	Heater 6 Minimum Temp		
		0	Heater 6 Maximum Temp		
		0	Heater 7 Minimum Temp		
		0	Heater 7 Maximum Temp		

		0	Heater 8 Minimum Temp		
		0	Heater 8 Maximum Temp		
1SRTAQ	Start Data Acquisition	0	5	0	1
1STPAQ	Stop Data Acquisition	0	5	0	2
1RESET	Hyperion Reset	0	6	0	1
1GOIDL	Go to Idle Mode	0	6	0	2
1GOSBY	Go to Standby Mode	0	6	0	3
1SFHLD	Go to Safe Hold Mode	0	6	0	4
1POKBT	Poke 8-bit	0	7	0	1
		Offset			
		Segment			
		Data			
1POKWD	Poke 16-bit	0	7	0	2
		Offset			
		Segment			
		Data			
1POKLG	Poke 32-bit	0	7	0	3
		Offset			
		Segment			
		Data (low)			
		Data (high)			
1PKDAT	Peek	0	7	0	4
		Offset			
		Segment			
1CRTON	Start Cryo Telem Acq	0	8	0	1
1CRTOF	Stop Cryo Telem Acq	0	8	0	2

A2.3 Telemetry Packet

Most Significant Bits / Least Significant Bits

Description	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Semaphore	Semaphore (zero or unchanged means no new packet)															
Packet header 1	Version Number			Type	Sec. Header	Application Process ID										
Packet header 2	Segment Flags		Source Sequence Count													
Packet header 3	Packet Length															
Secondary Hdr1	Time code: Most Significant Word															
Secondary Hdr2																
Secondary Hdr3																
Secondary Hdr4	Time code: Least Significant Word															
Status	Cal Lamp 2 1 = on	Cal Lamp 1 1 = on	Cover Status 0 = closed 1 = calibrate 2 = open		Data Collect	Standby	Watch-Dog Reset	SC Reset	Heater7 1 = On	Heater6 1 = On	Heater5 1 = On	Heater4 1 = On	Heater3 1 = On	Heater2 1 = On	Heater1 1 = On	Heater0 1 = On
Heater 0 Min	Not Used				+ X Panel Heater Minimum temperature setpoint											
Heater 0 Max	Not Used				+ X Panel Heater Maximum temperature setpoint											
Heater 1 Min	Not Used				+Y Panel Heater Minimum temperature setpoint											
Heater 1 Max	Not Used				+Y Panel Heater Maximum temperature setpoint											
Heater 2 Min	Not Used				-X & -Y Panel Heater Minimum temperature setpoint											
Heater 2 Max	Not Used				-X & -Y Panel Heater Maximum temperature setpoint											
Heater 3 Min	Not Used				Top Panel Heater Minimum temperature setpoint											
Heater 3 Max	Not Used				Top Panel Heater Maximum temperature setpoint											
Heater 4 Min	Not Used				Botton Panel Heater Minimum temperature setpoint											
Heater 4 Max	Not Used				Botton Panel Heater Maximum temperature setpoint											
Heater 5 Min	Not Used				VNIR ASP Heater Minimum temperature setpoint											
Heater 5 Max	Not Used				VNIR ASP Heater Maximum temperature setpoint											
Heater 6 Min	Not Used				SWIR ASP Heater Minimum temperature setpoint											
Heater 6 Max	Not Used				SWIR ASP Heater Maximum temperature setpoint											
Heater 7 Min	Not Used				Heater 7 Minimum temperature setpoint											
Heater 7 Max	Not Used				Heater 7 Maximum temperature setpoint											
Cal Lamp 1 Value									In-Flight Calibration Lamp 1 Commanded Value							
Cal Lamp 2 Value									In-Flight Calibration Lamp 2 Commanded Value							
Cal Lamp 1 Current	Not Used				In-Flight Calibration Lamp 1 Current											
Cal Lamp 2 Current	Not Used				In-Flight Calibration Lamp 2 Current											
Cal Lamp 1 Voltage	Not Used				In-Flight Calibration Lamp 1 Voltage											
Cal Lamp 2 Voltage	Not Used				In-Flight Calibration Lamp 2 Voltage											
HSA Temp1	Not Used				+ X Panel Temperature											
HSA Temp2	Not Used				+Y Panel Temperature											
HSA Temp3	Not Used				-X & -Y Panel Temperature											
HSA Temp4	Not Used				Top Panel Temperature											
HSA Temp5	Not Used				Bottom Panel Temperature											

HSA Temp6	Not Used	VNIR FPE Temperature				
HSA Temp7	Not Used	VNIR ASP Temperature				
HSA Temp8	Not Used	SWIR ASP Temperature				
Spare Temp	Not Used	Spare Temperature				
Spare Temp	Not Used	Spare Temperature				
Spare Temp	Not Used	Spare Temperature				
OMS Temp	Not Used	OMS Temperature				
Baffle Temp	Not Used	Baffle Temperature				
Cooler Temp	Not Used	Cooler Temperature				
VNIR FPGA Temp	Not Used	VNIR FPGA Temperature				
HPE Temp	Not Used	HPE Temperature				
HEA +5V	Not Used	HEA +5V				
HEA +15V	Not Used	HEA +15V				
HEA –15V	Not Used	HEA –15V				
VNIR +5VD	Not Used	VNIR +5VD				
VNIR +5VA	Not Used	VNIR +5VA				
VNIR –5VA	Not Used	VNIR –5VA				
VNIR +15VA	Not Used	VNIR +15VA				
VNIR –15VA	Not Used	VNIR –15VA				
SWIR +5VD	Not Used	SWIR +5VD				
SWIR +5VA	Not Used	SWIR +5VA				
SWIR –5VA	Not Used	SWIR –5VA				
SWIR +15V	Not Used	SWIR +15V				
SWIR –15V	Not Used	SWIR –15V				
Cover Position	Not Used	Cover Position				
Spare Analog Telem	Not Used	Spare Analog Telemetry				
Spare Analog Telem	Not Used	Spare Analog Telemetry				
SWIR Param 1	SWIR Offset B (Range 0 to 255)		SWIR Offset A (Range 0 to 255)			
SWIR Param 2	SWIR Offset D (Range 0 to 255)		SWIR Offset C (Range 0 to 255)			
SWIR Param 3	SWIR Integration Time		SWIR Gain D (0-3)	SWIR Gain C (0-3)	SWIR Gain B (0-3)	SWIR Gain A (0-3)
VNIR Parameters	VNIR Offset D (Range 0 to 15)	VNIR Offset C (Range 0 to 15)	VNIR Offset B (Range 0 to 15)		VNIR Offset A (Range 0 to 15)	
Peek Offset	Offset Address from peek command					
Peek Segment	Segment Address from peek command					
Peek Data Low	Least significant word of peek data					
Peek Data High	Most significant word of peek data					
Command Buffer 0	Most recently received command opcode					
Command Buffer 1						
Command Buffer 2						
Command Buffer 3						
Command Buffer 4	Fifth most recently received command opcode					
Error Buffer 0	Most recently recorded error condition					
Error Buffer 1	Second most recently recorded error condition					
Cryocooler Telem Semaphore	Cryocooler telemetry semaphore (zero or unchanged means no new cryocooler telemetry packet)					
Cryocooler Telem 0	0xEB90					

Cryocooler Telem 1	0x0430
Cryocooler Telem 2	0x1002
Cryocooler Telem 3	Header Checksum
Cryocooler Telem 4	Most significant word of timer
Cryocooler Telem 5	Least significant word of timer
Cryocooler Telem 6	Cold head temperature
Cryocooler Telem 7	Electronics temperature 2
Cryocooler Telem 8	Center plate temperature
Cryocooler Telem 9	+ Peak drive, side 1
Cryocooler Telem 10	- Peak drive, side 1
Cryocooler Telem 11	+ Peak drive, side 2
Cryocooler Telem 12	- Peak drive, side2
Cryocooler Telem 13	Status Word 0
Cryocooler Telem 14	Status Word 1
Cryocooler Telem 15	Status Word 2
Cryocooler Telem 16	Electronics temperature 1
Cryocooler Telem 17	DC setpoint side 1
Cryocooler Telem 18	DC setpoint side 2
Cryocooler Telem 19	Average peak input current
Cryocooler Telem 21	Average Current side 1
Cryocooler Telem 22	Average Current side 2
Cryocooler Telem 23	5V supply
Cryocooler Telem 24	+12V supply
Cryocooler Telem 25	-12V supply
Cryocooler Telem 26	+60V supply
Cryocooler Telem 27	-60V supply
Cryocooler Telem 28	10 Log10(RSS of all harmonics)
Cryocooler Telem 29	Vibration level 1
Cryocooler Telem 30	Vibration level 2
Cryocooler Telem 31	Vibration level 3
Cryocooler Telem 32	Vibration level 4
Cryocooler Telem 33	Vibration level 5
Cryocooler Telem 34	Vibration level 6
Cryocooler Telem 35	Vibration level 7
Cryocooler Telem 36	Vibration level 8
Cryocooler Telem 37	Vibration level 9
Cryocooler Telem 38	Vibration level 10
Cryocooler Telem 39	Vibration level 11
Cryocooler Telem 40	Vibration level 12
Cryocooler Telem 41	Vibration level 13
Cryocooler Telem 42	Vibration level 14
Cryocooler Telem 43	Vibration level 15
Cryocooler Telem 44	Vibration level 16
Cryocooler Telem 45	Xloops
Cryocooler Telem 46	Vloops

Cryocooler Telem 47	Motor drive
Cryocooler Telem 48	Packet Checksum (Telemetry packet only)

A2.4 Hyperion Cryo-cooler Command Packet

Cryocooler Command Packet	# of Words
Header	4
Command	Up to 261

A2.5 Hyperion Cryo-cooler Command List

The complete Hyperion cryo-cooler command list is documented in D26977, TES FPC Control Software: Architecture and Software User's Manual, P.32-182.

A2.6 Hyperion Cryo-cooler Telemetry Packet

Cryocooler Telemetry Packet	# of Words
Semaphore	1
Header	7
Data	Up to 261

A2.7 Hyperion Cryo-cooler Telemetry List

The complete Hyperion cryo-cooler telemetry list is documented in D26977, TES FPC Control Software: Architecture and Software User's Manual, P.185-205.

Appendix 3. 32-wire RS-422 Image Data Format

A3.1 Hyperion Image Data Format
A3.1.1 Hyperion VNIR Image Data Format

Count N	Hyperion VNIR Data Format					
	DB(0:7)	DB(8:15)	DB(16:23)		DB(24:31)	
1	VNIR ID	**TC8**	TC7		**TC6**	
2	VNIR ID	TC5	TC4		TC3	
3	VNIR ID	XX	OSD	OSC	OSB	OSA
4	VNIR ID	Sync Time	Frame #			
	(LSB) DB0:11 (MSB)	DB 12:15	(LSB) DB16:27 (MSB)		DB 28:31	
5	VNIR Data Word 1	VNIR ID	VNIR Data Word 2		VNIR ID	
6	VNIR Data Word 3	VNIR ID	VNIR Data Word 4		VNIR ID	
-----	-----	-----	-----		-----	
-----	-----	-----	-----		-----	
8963	VNIR Data Word 17917	VNIR ID	VNIR Data Word 17918		VNIR ID	
8964	VNIR Data Word 17919	VNIR ID	VNIR Data Word 17920		VNIR ID	

Note. VNIR ID is "1".

A3.1.2 Hyperion SWIR Image Data Format

Count N	Hyperion SWIR Data Format					
	DB(0:7)	DB(8:15)			DB(16:23)	DB(24:31)
1	SWIR ID	**TC8**			TC7	**TC6**
2	SWIR ID	TC5			TC4	TC3
3	SWIR ID	INT Time			OSD	OSC
4	SWIR ID	GD	GC	GB	GA	OSB	OSA
5	SWIR ID	Sync Time			Frame #	

Count N	(LSB) DB0:11 (MSB)	DB 12:15	(LSB) DB16:27 (MSB)	DB 28:31
6	SWIR Data Word 1	SWIR ID	SWIR Data Word 2	SWIR ID
7	SWIR Data Word 3	SWIR ID	SWIR Data Word 4	SWIR ID
-----	-----	-----	-----	-----
-----	-----	-----	-----	-----
22020	SWIR Data Word 44029	SWIR ID	SWIR Data Word 44030	SWIR ID
22021	SWIR Data Word 44031	SWIR ID	SWIR Data Word 44032	SWIR ID

Note. SWIR ID is "2".

A3.1.3 Time Code Definition

Spacecraft Time Code							
Seconds				Sub-seconds			
TC8	TC7	TC6	TC5	TC4	TC3	TC2	TC1
Time Code Used in Hyperion Image Data Header							

Swales Recommended Changes to Hyperion ICD
(B. Northcutt & K. Brenneman, Swales, 12/8)

Below are recommended changes to the present (November 9,1998) version of the Hyperion ICD. Most of these changes come from the Swales leads for the engineering areas listed.

A number of the changes are changes in wordings and require no further action other than approval. However, there are also changes that are new TBDs. Most of the TBDs will require inputs from TRW (sorry about that TRW). All TBDs are specifically identified in the changes listings below. In addition, a TBD table is given compiling all the TBDs, with the new TBDs added onto the TBD listing presently accompanying the Nov. 9 ICD (at the EO-1 website).

ICD Status:
The consensus on the EO-1 project is that the majority of the technical information for TBD inputs already exists, and that the critical engineering inputs between the various parties has already been established. Hopefully then this last round of changes should present no surprises, and that closure to a completed ICD is at hand.

Recommended Changes Listings:

Numbering:

1. Due to changes that have occurred over time, some Sections and Figures are no longer consistent with the numbering scheme and require renumbering.

Documents

1. Section 1.5.2 : Change EO-1 I&T Plan to "Rev. D"

Electrical

1. Section 3.1, first paragraph, last sentence, change to read, "The Interconnecting Harness will be supplied by the instrument contractor, and the Spacecraft to Instrument Harness will be supplied by the spacecraft contractor. Both harnesses are to be routed by the spacecraft contractor."
2. Section 3.4, Figure 3.4-1, row marked J103 in table has a description which implies that it connects directly to the spacecraft, when Figure 5.2-1 shows that it connects to the HEA. Change from "S/C I/F" to "CEA to HEA I/F".
3. Section 5.2, first paragraph, last sentence, change to read, "The Interconnecting Harness will be supplied by the instrument contractor, and the Spacecraft to Instrument Harness will be supplied by the spacecraft contractor. Both harnesses are to be routed by the spacecraft contractor."
4. TBD - Section 5.2, Figure 5.2-1, Many connectors are missing "J" numbers.
5. Section 5.7, remove comment "NEED AN INSTRUMENT GROUNDING DIAGRAM", and replace all references to "AM-144-0020(155)" with "AM-14**9**-0020(155)". Add a third sentence that says, "The instrument grounding scheme shall conform to the requirements detailed in AM-149-0020(155). "
6. TBD - Appendix 1, To build the connectors for all Spacecraft Harnessing (Power Connector, Temperature Monitor Connector, RS-422 Connectors, Fiber Optic Connector), Swales will need twist group, wire gauge, and shielding information. Recommend a reference in Appendix 1 that calls out a TRW generated wire list document. Alternately, a wire list section could be added to Appendix 1. This change addresses the comment presently in Section A1.1.1. Similar information for the Interconnect Harness is not required in this ICD.
7. TBD - Appendix 1, Section A1.1.2, Table A1.1.2-1, add the specific connector part number to the title.
8. TBD - Appendix 1, Section A1.1.3, Table A1.1.3-1, add the specific connector part number to the title.
9. TBD - Appendix 1, Section A1.1.4, Table A1.1.4-1, add the specific connector part number to the title, as well as a J# reference(e.g. J101).
10. TBD - Appendix 1, Section A1.2, Table A1.2.2-1, add the specific connector part number to the title.
11. TBD - Appendix 1, Section A1.2, Table A1.2.2-2, add the specific connector part number to the title.
12. TBD - Appendix 1, add Section A1.3, Hyperion Fiber Optic Connector.
13. Section 7 Note : The GSFC WARP team will need to review this section, and interface with TRW and Swales.

Mechanical

1. TBD– Section 4.8.3.4, Alignment Procedure callout #
2. Section 12.1.2.2, change title of the first table from "Protoflight test limits" to "Test Factors"
3. Section 12.1.2.2, change title of the second table from "No-test limits" to "No-test Factors"
4. Section 12.2.2.2, change title of Table 12.2.2.2-1a from "Random Vibration Test Levels for the Hyperion HSA" to "Acceptance Random Vibration Test Levels for the Hyperion HSA Flight Unit"
5. Section 12.2.2.2, change title of Table 12.2.2.2-1b from "Random Vibration Test Levels for the Hyperion HSA" to "Protoflight Random Vibration Test Levels for the Hyperion HEA, CEA, and HSA STM structure"
6. TBD– Section 12.2.2.1, fill in third part of Table 12.2.1-3
7. TBD– Section 4.5, second paragraph : Solar calibration FOV requires further definition here (angle w.r.t. x-axis in x/y plane). Recommend adding a drawing reference.
8. TBD– Section 8.1.2 : Clarification of use of "knowledge" vs. "error"
9. TBD– Section 8.2.1 : Operations document reference ?
10. Section 12.2.2.2, add the following:

    Preliminary notched specifications have been calculated based on the Hyperion finite element model(FEM). The actual notch used during testing may be based on this specification, but will have to be modified to account for frequency shifts, mode shape changes, and damping changes, relative to the FEM. Project concurrence will be required for the final test specification.

Table 12.2.2.2-2a Preliminary Notched Acceptance Random Vibration Test Specification

X Direction		Y Direction		Z Direction	
Frequency (Hz)	Magnitude (g^2/Hz)	Frequency (Hz)	Magnitude (g^2/Hz)	Frequency (Hz)	Magnitude (g^2/Hz)
20	0.0129	20	0.0129	20	0.0129
50	0.08	50	0.08	50	0.08
80	0.08	60	0.08	110	0.08
100	0.000347	70	0.0006	130	0.005
140	0.000347	90	0.0006	190	0.005
160	0.08	100	0.08	210	0.0005
200	0.08	140	0.08	250	0.0005
210	0.017	150	0.04	300	0.08
230	0.017	170	0.04	500	0.08
240	0.08	180	0.08	2000	0.0127
500	0.08	500	0.08		
2000	0.0127	2000	0.0127		

Table 12.2.2.2-2b Preliminary Notched Protoflight Random Vibration Test Specification

X Direction		Y Direction		Z Direction	
Frequency (Hz)	Magnitude (g^2/Hz)	Frequency (Hz)	Magnitude (g^2/Hz)	Frequency (Hz)	Magnitude (g^2/Hz)
20	0.0258	20	0.0258	20	0.0258
50	0.16	50	0.16	50	0.16
80	0.16	60	0.16	110	0.16
100	0.000694	70	0.0012	130	0.01
140	0.000694	90	0.0012	190	0.01
160	0.16	100	0.16	210	0.001
200	0.16	140	0.16	250	0.001
210	0.034	150	0.08	300	0.16
230	0.034	170	0.08	500	0.16
240	0.16	180	0.16	2000	0.0254
500	0.16	500	0.16		
2000	0.0254	2000	0.0254		

Integration and Test

1. 12.5 : Delete the repeated paragraph.
2. Fig 12.2.8.1–1 : Add +28V+/-7Vdc between Spacecraft and Hyperion Flight Hardware.
3. TBD - 14.7 : Swales will also need a thermal model for the 1st Spacecraft TV/TB Test.
4. TBD– Section 14.5.1: fill in shipping container maximum accelerations and locations
5. Section 13.2, first sentence : change "shall" to "shall comply with"
6. TBD– Section 13.3 : Swales needs required purge gas flow rate

Command and Telemetry:

1. 6.4 : Change second sentence in first paragraph to– The Hyperion (RT) 1773 controller shall be a Boeing 1300nm, Litton part number 900-60095-12 transceiver.
2. 6.5 : Change fourth sentence of first paragraph to– The Hyperion shall use the BOX_CMD and the HYP_CMD_SUBCOM schedules…
3. Figure 6.5-2 : Add the following maximum frequency limitations to the Command and Telemetry channels– RCH2 @ ¼ Hz, XCH2 @ ¼ Hz, XCH3 @ 1 Hz .
4. 6.8 : Change the first sentence of the last paragraph to– The "tone message" packet is a command packet with a 6-byte primary and a 2-byte secondary header, and command data consists of a 16 bit sequence counter and a 64 bit time code. Also, change spelling of "tune" to "tone" in following sentence.
5. 6.8 : Add this sentence to end of paragraph– The mock code sent shall be 8, 01000.

Thermal

1. 9.1 : Change this section to the following–

The HSA is mounted on an instrument platform that is attached to the spacecraft nadir deck. The instrument platform and associated hardware is designed to minimize the HSA conductive path to the spacecraft nadir deck. The thermal interface details are specified in the Hyperion drawing #868800-1.

The HEA and the CEA are mounted on an aluminum mounting plate attached to the nadir deck. The aluminum mounting plate is designed to provide a good conductive path to the HEA/CEA mounting surfaces and to the nadir deck. In addition to the conductive thermal control inherent to this design, designated areas of the HEA and CEA electronic boxes (top + sides) are used as passive radiators.

2. Table 9.2.1-1 : Add "N/A" to empty placeholders.
3. TBD - 9.3 : Swales would like to see callouts to the drawing defining HEA & CEA thermal interfaces, and ideally some pictorials similar to the HSA pictorials in Section 9.2 .
4. 9.3 : Change second to last sentence in paragraph– The spacecraft deck is maintained between 0 to 30 Celsius.
5. Table 9.2.2-1 : Add "N/A" to empty placeholders.
6. TBD– Section 9.3: Fill in TBDs for HEA and CEA Predicted Survival Temp. in Table 9.2.2-1
7. TBD - Section 9.3.1 : Change first paragraph to–

The power consumption of the HEA and CEA components is detailed in Figure 5.6-1. The conductive heat transfer from the HSA to the nadir deck through the HEA/CEA mounting plates, at (<u>TBD</u> Watt/degree) shall be within the -<u>TBD</u>W (heat flow from Spacecraft to Hyperion) to +<u>TBD</u>W (heat flow from Hyperion to Spacecraft) range.

8. 9.3.1 : Change word "Figure" to "Table" in second paragraph.
9. 9.3 : Change spelling from "with" to "which" in second sentence of paragraph.

All

1. Add "N/A" to all empty placeholders in tables throughout ICD.

TBD Table:

Section	Description	Subsystem	Assignment
1.5.3	Hyperion Operators Manual #	Ops	Pearlman
	Hyperion Alignment Plan #	A&T	Iverson
3.2	HSA Purge Port Location	Mechanical	Rasmussen
3.3	HEA ICD Drawing(connector locations)	Electrical	Kien
4.10	Cover Inertia	Mechanical	Rassmusen
5.2	Cable Diagram Details	Electrical	Kien
5.7	Grounding Diagram (Swales Note: See recommended change in "Electrical" section above to close this TBD)	Electrical	Kien
9.3.1	HEA/CEA to S/C Heat Flow (Swales Note: See recommended change in "Thermal" section above for new wording in which these TBDs will be imbedded. This TBD is repeated below)	Thermal	Rasmussen
12.3.1	Functional Test Procedure #	A&T	Iverson
The below Items are new or were not included in the above list.			
4.8.3.4	Alignment Procedure callout #		
5.2	Figure 5.2-1, Many connectors are missing "J" numbers.		
9.3	Table 9.2.2-1, HEA and CEA Predicted Survival Temperatures		
12.2.2.1	Fill in third part of table		
14.5.1	Shipping container accel number and locations		
A1	Note: to build the connectors for Spacecraft Harnessing, we will need wire list documentation (see listing above for recommended form)		
A1.1.2,	Table A1.1.2-1, add the specific connector part number to the title.		
A1.1.3	Table A1.1.3-1, add the specific connector part number to the title.		
A1.1.4	Table A1.1.4-1, add the specific connector part number to the title, as well as a J# reference(e.g. J101).		
A1.2	Table A1.2.2-1, add the specific connector part number to the title.		
A1.2	Table A1.2.2-2, add the specific connector part number to the title.		
New	Add Section A1.3, Hyperion Fiber Optic Connector.		
14.7	Callout for provision of thermal model for the 1st Spacecraft TV/TB Test		
9.3	Callouts to the drawing defining HEA & CEA thermal interfaces, and pictorials similar to HSA pictorials		
9.3.1	HEA/CEA heat transfer TBD fill in's (3) (Note: This is repeated from the original TBD table, and is included here due to recommended changes of the wording in which the TBDs are to be imbedded)		
4.5	More definition for Solar Cal. FOV		
8.1.2	Clarification of use of "knowledge" vs. "error"		
8.2.1	Operations document reference ?		
13.3	Add required purge gas flow rate		